Flapper Peening picks up speed

PLUS:
New Products are Problem Solvers
Almen Strip Consistency Testing

2008 Shot Peener of the Year
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Flapper Peening Picks Up Speed

Flapper peening usage is growing in aerospace maintenance, repair and overhaul facilities. Find out what is contributing to the rise of this portable peening process.

Two New Products are Problem Solvers

Control and coverage validation are two crucial aspects of the shot peening process. Shockform has developed products that help peening operators obtain both.

Articles

2008 Shot Peener of the Year  P.12

If you have attended an EI Shot Peening Workshop, you’ve probably met our 2008 Shot Peener of the Year. He is an engineer with a leading German aero engine manufacturer and maintenance facility. Can you guess who he is?

Almen Strip Consistency Testing  P.14

Before bringing their Almen strips to market, EI developed a custom air blast test cabinet and shot peened approximately 4,000 strips manufactured over a three-year period. Review the results of their testing program.

Blasting High-Precision Tools for High-Precision Surgery  P.18

A blast cleaning solution from Herb Tobben
Flapper peening (also called roto-peening) looks like such a small, delicate process—more like jewelry making than shot peening. But don’t let the equipment size fool you. Flapper peening’s benefits are huge and its usage is growing in aerospace maintenance, repair and overhaul (MRO) facilities.

FLAPPER PEENING WAS THE ANSWER
During the Vietnam war, U.S. Army helicopters were used in greater numbers than ever before in a land war. Repair and maintenance had to be fast and effective, especially on components like rotors. Shot peening was needed but taking the aircraft out of service for any length of time wasn’t an option.

3M™ had the solution. The company worked with tool manufacturers to adapt their TC330 roto peening flap assembly to a flexible shaft tool. The resulting 3M™ Roto Peen Flap Assembly had a small footprint, was portable, and replaced free-flying shot. Because it was capable of repairing gouges, scrapes and corrosion in small and hard-to-reach areas, it was ideal for peening helicopter components like rotor hubs.

In the early 1970s, the TC330 was qualified at Wright-Patterson Air Force Base in Dayton, Ohio and written into the military specifications MIL-R-81840 and MIL-R-81841. Its usage quickly spread to civilian aerospace companies that appreciated its portability and effectiveness.

Flapper peening, however, wasn’t limited to the field of aviation. Dr. David Kirk, Visiting Professor in Materials, Faculty of Engineering and Computing at Coventry University, used flapper peening 20 years ago at a billion-dollar steam turbine facility. During commissioning, fatigue cracks started to appear at the roots of the blade/rotor fir-tree assemblies. These areas had not been peened prior to assembly. Disassembly and shipping parts halfway around the world would have cost millions of dollars. “Acting as a consultant, I carried out flapper peening on test blocks followed by the determination of induced residual compressive stress profiles. Results were so encouraging that flapper peening was subsequently carried out in situ on the steam turbine assemblies. To the manufacturer’s great relief,

The 3M™ Roto Peen Flap Assembly is a captive shot flap technology that uses high strength resin to bond tungsten carbide shot to a flexible polymeric flap. This provides a cleaner, more precise method than loose shot peening and the uniform 330 shot size contributes to consistent results. The two polymeric flaps are bonded together with a specially formulated adhesive matrix for easy placement in a flap mandrel.

Applications include:
- Landing gear assemblies
- Wing structures
- Helicopter rotor hubs
- Jet engine support members
- Peening after grinding
- Peening before plating
- Peening of surfaces subject to stress corrosion
- Peen straightening
- Peen forming
- Weld heat affect zone
- Bond testing

RESOURCE: 3M™ Roto Peen Flap Assemblies TC330 Application Notes
Whether you are peening large areas with centrifugal wheels or targeting specific areas with automated airblast nozzles, Wheelabrator Group will deliver the right solution to meet your need.

Your investment in Wheelabrator technology and equipment will lead to consistent and repeatable peening results with both types of media propulsion techniques.

Shown right: Wheelabrator Model® LGA-08 Landing Gear System, picture courtesy of Hawker Pacific Aerospace

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no further fatigue failures were encountered in service,” said Dr. Kirk.

FLAPPER PEENING IN TODAY’S MRO FACILITIES
As evidenced by Dr. Kirk, flapper peening can be used in other fields besides aviation but its greatest usage is in MRO. We asked Dave Barkley, a flapper peening trainer with Electronics Inc. Education Division, for his viewpoint on flapper peening’s popularity.

**Shot Peener:** Who is using flapper peening today?

**Mr. Barkley:** We’re training staff from large aerospace companies, U.S. military bases and small, independent shops.

**Shot Peener:** Flapper peening looks easy, why would you need training?

**Mr. Barkley:** Flapper peening is a manual process and the operator is responsible for more than just pushing a button to initiate a typical automated peening process. Putting residual compressive stress back into the repaired area is as important as the initial shot peening but the flapper peening technician needs to follow different rules from conventional peening and use specific techniques to make it a controlled process.

**Shot Peener:** Who attends flapper peening training?

**Mr. Barkley:** In most cases our students are machine operators and artisans that have never worked with shot peening. That’s why we make sure our flapper peening training includes a thorough review of all aspects of shot peening.

**Shot Peener:** What components will your students be flapper peening?

**Mr. Barkley:** They’re using flapper peening on previously-peened parts that are in for repair or maintenance and require peening on the worked areas. Practically any component that was shot peened can be flapper peened. The big advantage for our customers is when they can repair and peen components like landing gear parts or helicopter rotor hubs without disassembling them. Even sensitive assemblies can be flapper peened because there is no stray media. I don’t see it very often, but flapper peening is also used for part straightening or forming.

**Shot Peener:** What do your students think of flapper peening after training?

**Mr. Barkley:** They are excited about what they have learned. Exposing them to the theory and benefits of shot peening gives them an appreciation for what they are doing. They leave the training with a new sense of pride in their craft.

**Flapper Peening Saves Time and Money for KLM**
KLM Royal Dutch Airlines’ Engineering and Maintenance Division uses flapper peening for several reasons. One big reason is the size of the parts that need to be peened—they don’t fit in a shot peening cabinet. An example is a flaptrack of an airplane. Flaptracks are located in wings and can be up to 8 feet in length. “Often the holes in the flaptrack need mechanical rework and then require shot peening,” said Marcel van Wonderen, KLM’s Master Engineer on Process, Equipment and Materials Development. “In that case, we use flapper peening on the holes.”

Sometimes the type of damage calls for flapper peening. “Recently, a landing gear was dented. We had to blend away the dent, which is an initiation point for micro-cracking, and used flapper peening to introduce compressive stress on the blended area,” said Mr. van Wonderen.

Additionally, KLM flapper peens parts that have to be peened on site. Oxide removal with blending is typically done locally and KLM’s mechanics flapper peen the worked area to compensate for the tension stress induced by the blending and to increase resistance to oxidation.

**KLM flapper peens small areas on large components, like the holes in the flaptrack from a wing.**
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Flapper peening’s convenience and portability saves money for KLM. In the case of the dented landing gear mentioned above, it would have cost $80,000 to remove the landing gear from the plane, take the landing gear apart and send the part to the engine shop. Figured into the cost is also the repair activities and turn-around time of three days (turn-around time is a big issue in the aircraft overhaul business). “The whole flapper peening procedure was completed in only 20 minutes and cost maybe $150,” said Mr. van Wonderen. Some repairs, such as removing oxide spots and peening afterwards, can only be done with flapper peening. Mr. van Wonderen asked, “How do you calculate the cost savings on that?”

THE FUTURE OF FLAPPER PEENING

Two advancements are enhancing flapper peening’s position as a viable, controllable process: a relevant and accurate specification and a RPM controller. The SAE Aerospace Metals Engineering Division’s Shot Peening Sub-Committee is developing an AMS version of a flapper peening specification intended to displace the MIL-R-81841 specification. MIL-R-81841 has several erroneous concepts and requirements.

Shockform’s FlapSpeed™ controller brings a new level of control and confidence to the flapper peening procedure. “Several of our clients in the aerospace sector have told us that they liked the flexibility, speed and cleanliness of flapper peening but they wished that the process was more controlled,” said Sylvain Forgues, co-owner of Shockform. Furthermore, new requirements such as the Nadcap audit criteria AC7117/4 requires that companies use “flapper peening equipment capable of maintaining the required RPM to consistently conform to the required intensity values”. Until now, this requirement was difficult to fulfill since no RPM controller was commercially available for flapper peening. The recently-released patented controller is small, robust and easy to use in a production or MRO environment. “It will help users meet their quality requirements for the flapper peening process,” said Mr. Forgues.

Resources
3M™ Roto Peen Flap Assemblies TC330
Electronics Inc. 1-800-832-5653 or 1-574-256-5001 www.electronics-inc.com

Flapper Peening Training
Dave Barkley, Flapper Peening Training Specialist Electronics Inc. Education Division dave.barkley@electronics-inc.com

FlapSpeed™ Controller
Sylvain Forgues, co-owner of Shockform Inc. 1-450-430-8000 info@shockform.com or www.shockform.com

Get up to speed on flapper peening with flapper peening training from the experts

Flapper peening is ideal for repairing small and hard-to-reach areas. Flapper peening can be done in the field, making the time-consuming and expensive disassembly and transportation of components unnecessary.

Flapper peening is one of the fastest-growing shot peening methods—it’s effective, economical and fast. Electronics Inc. Education Division offers one-day on-site training programs for companies and military bases that want to expand their flapper peening skills.

Our flapper peening training will:
- Help you achieve a controllable process
- Increase your operators’ skill
- Demonstrate how to achieve compliance to specifications and standard practices
- Expand your use of this productive process

Our training program is beneficial to operators, supervisors, inspectors and application engineers.

Mechanics that are qualified under FAA rules to perform inspections may receive credit for taking this class.

Ask us for more information.
1-800-832-5653 (U.S. and Canada) or 1-574-256-5001
or visit www.electronics-inc.com

Get flapper peening training from the company that knows how to do it right. Jack Champagne, President of Electronics Inc., is the Chairman of the Shot Peening Sub-Committee of the Aerospace Metals Engineering Committee of the Aerospace Materials Division of SAE. His committee will be responsible for writing the new flapper peening specification. EI provides flapper peening training to aerospace companies and military bases worldwide.
The advantages of Premier Cut Wire Shot

- **Highest Durability** - Due to its wrought internal structure with almost no internal defects (cracks, porosity, shrinkage, etc.) the durability of Premier Cut Wire Shot can be many times that of other commonly used peening media.

- **Improved Consistency** - Highest consistency from particle to particle in size, shape, hardness and density compared to commonly used metallic media.

- **Highest Resistance to Fracture** - Cut Wire Shot media tends to wear down and become smaller in size rather than fracture into sharp-edge broken particles which may cause damage to the surface of the part being peened.

- **Lower Dust Generation** - Highest durability equals lowest dust levels.

- **Lower Surface Contamination** - Cut Wire Shot doesn’t have an Iron Oxide coating or leave Iron Oxide residue - parts are cleaner and brighter.

- **Improved Part Life** - Parts exhibit higher and more consistent life than those peened with equivalent size and hardness cast steel shot.

- **Substantial Cost Savings** - The increase in useful life of Premier Cut Wire Shot results in savings in media consumption and reclamation, dust removal and containment, surface contamination and equipment maintenance.

The advantages of the Premier Shot Company

Premier Shot is proudly produced in the United States. It is manufactured to meet today’s high quality shot peening standards and is used in automotive and aerospace applications worldwide.

Premier Shot Company: 1203 West 65th Street • Cleveland, Ohio 44102
New Products are Problem Solvers

Shockform Inc. introduced two new products at the Electronics Inc. 2008 Shot Peening and Blast Workshop in Cincinnati, Ohio

Control and coverage validation are two crucial aspects of the shot peening process. Shockform has developed products that help peening operators obtain both.

EI Shot Peening Workshop attendees were able to try the new FlapSpeed™ Controller and InspectView™ 20/20 camera at Shockform’s exhibit. Now our readers can take a closer look at these easy-to-use products that will greatly improve the quality of your shot and flapper peening programs.

FlapSpeed™ Flapper Peening Controller
The FlapSpeed™ Controller was a big attraction at the workshop. The controller was tested by visitors to Shockform’s booth and it was presented by workshop instructors, Pete Bailey and Dave Barkley, during their Flapper Peening Theory and Application classes.

Flapper peening (or roto-peening) has been used since the 1960s but it has always lacked real-time rotational speed control. The FlapSpeed™ Controller addresses that problem: It continuously monitors and adjusts the rotational speed of the flap during the peening process. Because the peening intensity relies on the rotational speed, the flapper peening process now has increased stability and repeatability.

The patented controller was designed to be small, robust and easy to use in a production or Maintenance, Repair and Overhaul (MRO) environment. It comes in both electric and compressed air models and offers a direct input of peening intensity. The controller converts the requested intensity into the associated flap rotational speed. The time required to generate Almen intensity curves is reduced and the productivity of the operator is increased. Overall, the FlapSpeed™ controller reduces the setup time and makes flapper peening more reliable.

"Shockform is very proud of the controller because it brings a new level of confidence to the flapper peening process while making it faster and much easier than before," said Sylvain Forgues, co-owner of Shockform.

InspectView™ 20/20 Coverage Inspection Camera
Although achieving appropriate coverage is very important in the peening process, the best inspection tool to date has been a standard magnifier. The magnifier works for simple geometries but it isn’t viable when inspecting complicated geometries or areas that are difficult to access. Ironically, this is when a thorough coverage inspection is most important.

Shockform’s new InspectView™ 20/20 coverage inspection camera improves visual inspections. It features a 3.5-inch color monitor and a 39-inch long probe. The probe has a small diameter (0.23-inch) and four integrated LED that can be adjusted using a stepless wheel. The camera also features a series of 10X, 20X and 30X lenses for inspecting coverage and media as well as 35, 45 and 60 degree mirrors for inspecting the inside of bores. The InspectView™ 20/20 camera allows you to take pictures and movies that can easily be transferred to your computer through a SD card or a USB port and shared with colleagues, management or clients in prints or reports.

EI Workshop participants used the small camera to inspect the coverage of complicated parts as well as...
Easier and Faster with the FlapSpeed™ Controller

Here it is! The new way to do flapper peening. The FlapSpeed™ Controller offers what the industry has been waiting for: the continuous monitoring and adjustment of the flapper rotation speed to ensure repeatable and reliable peening.

Available for both electrical and compressed air flapper peening, the FlapSpeed™ Controller lets you select the required Almen intensity or the flapper RPM. No more precious time lost making endless saturation curves. The FlapSpeed™ Controller will give you less variability and more productivity. It is a better, easier and faster way to do flapper peening.

Find the FlapSpeed Controller and all your flapper peening needs at Shockform.com or call (450) 430-8000
peening media. Some even went as far as inspecting their friend’s mouth and ears. It is sometimes scary what one can find with advanced inspection tools!

### Product Review

**New Products from Shockform**

Sylvain Forgues and Brigitte Labelle are co-owners of Shockform Inc. Shockform has over 20 years of experience in fatigue life improvement through innovative peening products. Contact Shockform at 1-450-430-8000 or through their web site at www.shockform.com

### 2008 Shot Peener of the Year

*The Shot Peener* is proud to announce the recipient of its 2008 Shot Peener of the Year award—**Holger Polanetzki**.

Mr. Polanetzki is an Engineer of Metallurgy and a Designated Process Specialist Shot Peening/Grit Blast and GE Certifying Agent Shot Peening. MTU Aero Engines is Germany’s leading aero engine manufacturer and a global leader in commercial aero engine maintenance services. Mr. Polanetzki started working at MTU in 1986 with responsibility in several areas including chemical/electrochemical processes, thermal spray and mechanical processes. He conducts audits and consults on design, quality and manufacturing, and development and implementation of new technology such as ultrasonic shot peening. Mr. Polanetzki has achieved Electronics Inc. Shot Peening Level III certification status.

Mr. Polanetzki was chosen as the 2008 Shot Peener of the Year for his work in the Aerospace Metals Engineering Committee (AMEC) of the Aerospace Materials Division of SAE. He also contributes his time to the new shot peening sub-committee that is responsible for creating and updating shot peening specifications. “Mr. Polanetzki travels to the U.S. several times a year to participate in committee meetings and his perspective on the European workplace has made a major contribution to the committee’s work,” said Jack Champaigne, Chairman of the AMEC shot peening sub-committee and Editor of *The Shot Peener* magazine.

Mr. Polanetzki was the Keynote Speaker at the Shot Peening and Blast Cleaning Workshop in Cincinnati, Ohio in October. His presentation on MTU Aero Engines included a preview of their next generation engine and their shot peening processes.

The Shot Peener of the Year award program was initiated in 1992 by *The Shot Peener* magazine as a way to recognize academic and industry leaders that make significant contributions to the advancement of shot peening.

Holger Polanetzki received his 2008 Shot Peener of the Year plaque from Jack Champaigne at the 2008 U.S. Shot Peening and Blast Cleaning workshop.
Electronics Inc. Certifies Almen Strips

- Proven in the field
- Consistent quality
- Repeatable performance
- Trusted worldwide

Electronics Inc. manufactures and maintains the world’s largest inventory of Almen strips for worldwide distribution. EI can provide strips to any specification, from standard MIL specifications to rigid aerospace specifications. Almen A, N or C strips in GradesSM 3, 2, 1 and I-S are ready-to-use and are pre-qualified. Due to EI’s heat treatment process, additional benefits of the strips include improved control of hardness and flatness as well as eliminating the potential for decarburization.
SUMMARY
Shot peening intensity is the measure of the energy of the shot stream and intensity control is one of the essential means of meeting peening specifications. Intensity is measured using Almen strips. When an Almen strip is shot peened, the residual compressive stress causes the Almen strip to bend or arc toward the peened side. The Almen strip arc height is a function of the energy of the shot stream and is very repeatable. Therefore, for Almen strips to provide reliable and repeatable intensity verification, it is critical that they are consistent in thickness, flatness and hardness.

Electronics Inc. (EI) brand of Almen strips have undergone extensive testing to ensure consistency from lot to lot. Before bringing their Almen strips to market, EI developed a custom air blast test cabinet and shot peened approximately 4,000 strips manufactured over a three-year period. The data was put into histograms for accurate analysis.

The histograms show nearly identical lot-to-lot arc height results. For example, the means range from 11.99 to 12.14 (0.001-inch units) and standard deviations range from 0.096 to 0.185. (Histogram samples are available on page 16.) EI's testing capabilities and test results validate EI's ability to produce reliable Almen strips.

INTRODUCTION
Electronics Inc., a manufacturer of products that control and improve shot peening processes, has been a worldwide supplier of Almen strips for over 21 years. In 2008, EI launched their own brand of A and N Almen strips to meet increasing demand for their strips in the aerospace industry and to better control the quality of the product. During research and development, EI began consistency testing to quantify the strips' performance and to develop documented confirmation that the strips were manufactured under conditions more stringent than SAE J442 specifications.

TESTING METHOD
EI built an air blast cabinet with a variable speed rotary table with 26 Almen strip holders, a fixture for adjusting nozzle distance from the strips, a MagnaValve for media flow rate control, and controls to adjust air pressure and table rotation. During testing, the table was rotated at a fixed speed, and the cabinet was set for a specific pressure and constant media flow rate so each strip passed under the blast nozzle at the same angular velocity for the same predetermined number of revolutions.

For each test, a sample size of 40 strips was used. These lots were produced in 2006, 2007 and 2008. EI measured and recorded the prebow of the strips before testing. After each test cycle, the arc heights were measured on a calibrated Almen gage and the prebow compensation was applied. The values were put into histograms for analysis.

TEST RESULTS
Histograms created over the three-year period exhibited nearly identical lot-to-lot arc height results, thereby verifying the uniformity of the product.

Four histograms are available on page 16. Each histogram represents a test completed to verify the performance of an individual lot. The results illustrate the performance consistency of the strips as defined by the nearly identical mean values and the narrow standard deviations.
IPS... Manufacturer of high quality automated shot peening and abrasive blasting machinery at an affordable price. Our intelligent motion computer controlled shot peening machines offer cutting edge electrical and media delivery technologies. Our systems are manufactured using 1/2” steel plate and we can customize a system specifically for any customer using proven components and experience. Other areas of expertise include blast rooms, job shop shot peening and coatings, plastic media blasting and machine repair and modifications.

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In addition to documented consistency results, this testing program has provided a substantial technical support base for EI's Almen strip customers. EI has available:

- Current lot-to-lot comparison data on EI strips
- Comparisons of EI strips to other strips
- Performance data on other strips
- Analysis on the effect of variations in manufacturing parameters (hardness, thickness, etc.)

EI's research is thoroughly documented. For each test, EI records the scope, setup parameters, procedures, test results and analysis, histograms, saturation curves (where applicable), and a summary conclusion.

EI uses the performance data to answer customers' questions related to process variables and to help customers identify performance problems such as arc height variations and out-of-spec results with non-EI strips.

When EI does not have data available on a unique problem, EI will perform tests to analyze a customer's problem or even duplicate, as closely as possible, their process setup.

**About Histograms**

A histogram is a graphical display of tabulated frequencies, shown as bars. It shows what proportion of cases fall into each of several categories. A histogram differs from a bar chart in that it is the area of the bars that denotes the value, not the height of each bar as in bar charts.

**About Mean Value and Standard Deviation**

The mean is the sum of the observations divided by the number of observations. The mean describes the central location of the data, and the standard deviation describes the spread. The standard deviation is a statistic that tells how tightly all the examples are clustered around the mean in a set of data. When the examples are tightly grouped together and the bell-shaped curve is steep, the standard deviation is small. When the examples are spread apart and the bell curve is relatively flat, that signifies a relatively large standard deviation. In the case of the Almen strip testing, the tight standard deviation signifies the consistency of the arc height reading.

Each histogram represents a 40 piece sample size with the x-axis as the arc height of the strip after peening and the y-axis indicating the number of samples measured at that value. (Note: arc height values x .001 inches)
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Saint-Gobain Zirpro, your partner in high performance surface treatment ceramic media. Produced by electrofusion and used mainly for cleaning and finishing operations or shot peening. Zirblast and Zirshot can be used either in wheel turbine or in compressed equipment.

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Blasting High-Precision Tools for High-Precision Surgery

**Problem:**
Having an operation makes most people a little anxious. But knowing the surgeon is skilled and the instruments precise can allay fears, at least a little. For a good outcome, the surgeon and the hospital must do everything possible to cure the patient and avoid post-surgical infection.

Today, most surgical instruments are single-use, disposable tools. The practice of using instruments only once has dramatically increased demand for these tools and requires incredible production capacity.

I recently worked with one such manufacturer of very high quality medical instruments whose demand for precision exceeded almost any other application I’ve worked with, even compared with shot peening applications. Most of you know the stringent requirements associated with shot peening specifications, so this application was very special.

The company makes laparoscopic instruments, which are fabricated stainless steel tubes of very small diameter, with wall thicknesses between .010” to .017”, and some are over a foot long. The purpose of blasting is cleaning and deburring the parts. While blasting produces acceptable parts, the inherent issues associated with blasting are warping, distortion, and part growth. Due to high production demand, the company wanted to control the process themselves. They had experimented with sending the parts to a job shop and using a mix of glass bead and aluminum oxide, but they were dissatisfied with the level of rejected parts and they felt they were wasting time shipping parts back and forth waiting on new batches of parts. They strived for the right equipment solution, and the benefits it would bring to their operation.

**Solution:**
Their local ZERO distributor worked closely with them to articulate their needs and specify the challenges to be overcome. Once in the lab, we determined that we could produce good parts with 120-mesh aluminum oxide in a suction-style (venturi-style) indexing turntable blast cabinet, equipped with vertical oscillation. The machine had two blast stations, each with 4 blast guns, and could process six parts at a time.

The most challenging aspects of this application related to its very sensitive setup requirements. The customer required a very high degree of precision to maintain extremely tight tolerances due to the thinness of the stainless steel tubes. Each part had to be processed identically for a repeatable outcome. It was therefore critical that the position of the guns, the blast angle, the part rotation speed, and the media flow were identical for both stations.

In addition, maintaining the working media mix was critical. To accomplish this, an automatic media-add system was included so that small amounts of new media would be added at a determined interval to keep the media size consistent. The primary goals were repeatability and consistency.

The company puts the parts through a 100% inspection process that involves visual inspection and a specialized test bench to check concentricity tolerances and length to ensure that the parts meet their specification.

In the end, we were able to help the customer reduce cost by processing the parts in-house. Not only are they able to meet production demands more quickly, but also they are able to control variables, immediately respond to process issues, and eliminate the delays associated with batch processing at a distant location. They are saving time, saving money, and achieving an extremely high level of quality, making us proud to have contributed to this successful project.

Got a question about shot peening, abrasive blasting, or sample processing? Clemco can help.
Call Herb Tobben at 636 239-8172 or submit your request online at www.clemcoindustries.com
Herb Tobben is Sample Processing Manager for Clemco Industries Corp. He is a regular speaker at the EI Shot Peening Workshop.

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With two stations and fixtures to hold multiple parts, this semi-automated machine processes thousands of parts per day.

Special gun set up, satellite rotation speed, and media mix provides precise repeatability and consistent parts.
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We Have It All!

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- Portable Blasters • Hoffman Blast Rooms

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Size and Variability of Cast Steel Shot Particles

INTRODUCTION
Size is probably the most important property of cast steel shot. It affects saturation intensity, coverage rate and depth of work-hardened layer. Any variability of shot size is therefore important. Specifications, such as SAE J444 and AMS 2431, nominate cast steel shot size in terms of sieving results. Hence we have nominal shot sizes based on sieve mesh spacing. Cast steel shot size can also be associated with the diameter of a sphere. That is convenient because (a) cast steel shot particles are approximately spherical and (b) a sphere is the only geometrical figure that has only one dimension. Association of a particle’s size with sphere diameter is based on the concept of its “equivalent sphere”. The “equivalent sphere” of an individual shot particle is one that has the same volume as that of the particle (and therefore the same mass). Fig.1 illustrates the difference between sieve spacing and equivalent sphere as methods for sizing shot particles.

Fig.1 Cast steel shot particles on a nylon sieve.

Fig.2 Nominal shot sizes as specified in J444 – with equivalent spheres drawn to scale.

CAST STEEL SHOT

Fig.2 Nominal shot sizes as specified in J444 – with equivalent spheres drawn to scale.

component properties. On the other hand, the smaller the range the more expensive it is to produce and maintain shot that will satisfy the specification. We tend, however, to take specifications for granted, without considering their fundamental significance. It can be argued that:

“Specifications exist in order that a user can be assured that a product will be of a required standard”.

All peening specifications are based on the definition, measurement and variability restriction of particular parameters. These three factors should be clearly stated and be as unambiguous as possible.

New and used cast shot differ significantly in terms of their size distribution. Any given batch of shot gets smaller with use due to wear. Used shot will therefore contain worn particles and additions of new shot – together with a significant proportion of relatively-small particles – produced as shot breaks down in service. The terms “virgin shot” and “maintained shot” are appropriate to distinguish the two conditions. A completely new charge of shot can simulate steady-state maintained shot by using a “commissioning mix”. For example, maintained S230 can be simulated by mixing virgin shot grades of S110, S170 and S230.

NOMINAL SHOT SIZES

Nominal shot sizes give an indication of the average size of the particles in each class. If we assume that each shot particle is spherical and that the steel has a density of 7860 kg/m³ then we can calculate the average particle mass – see Table 1 on page 26.

A 100g sample is commonly specified for test purposes so that it is of some interest to note how many particles there are per sample. These range from millions to thousands.
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depending on shot size. 100kg of S110 circulating in a peening unit will consist of about a billion shot particles!

**PRODUCTION VARIABILITY**

Nominal shot size is a fixed quantity whereas actual samples contain a range of sizes. This range depends on production variability and associated screening procedures.

Cast steel shot is produced directly from the liquid state. The method employed is the prime cause of size variability. Liquid steel is poured from a ladle into high-pressure jets of water. The water jets break up the steel stream into tiny droplets that solidify to become shot particles. Droplets strive to reduce surface energy by minimizing the surface area-to-volume ratio. A spherical shape has the smallest surface area-to-volume ratio. Hence, as-cast shot particles approximate to spheres. Fig.3 illustrates possible variations of shot particle sizes produced by one ladleful of steel. These are close to what are called “normal distributions”. The distribution has a mean that can be controlled, to a limited extent, by factors such as water jet pressure and geometry. Variation about the mean can be quantified by its variance value (square of standard deviation).

The mass/size variations shown in fig.3 include only a small proportion of the most commercially-important shot sizes (such as S110, S170 and S230). A grit fraction could go directly to crushing - because the water-quenched state is very brittle. Normally, however, the whole output is classified, then austenized and quenched before rough screening to separate potential grit and shot fractions. The shot fraction is tempered and fine screened in order to yield different specification sizes of virgin shot.

Fine screening divides the shot fraction into sub-fractions – each of which will satisfy a corresponding standard specification. Precise details of fine screening are kept confidential by manufacturers. Fig.4 represents a possible screening routine designed to satisfy J444. Consider, for example, the S70 fraction - separated by having it pass through a 0.355mm sieve but not passing through a 0.125mm sieve. This would satisfy the J444 requirement of “All pass 0.425mm, 10% max on 0.355mm, 80% min on 0.180mm and 90% min on 0.125mm”. The S110, S170 and S270 fractions shown would also satisfy the corresponding J444 requirements.

![Fig 4 Possible screening system for cast steel shot.](image)

Each nominal size of virgin shot will contain a range of sizes. For S70 produced using the procedure indicated in fig.3 the size range would be from 0.125mm to 0.355mm in diameter. The mass of a shot particle is its volume multiplied by the steel’s density. Volume of a sphere is \( \frac{\pi d^3}{6} \) (d being diameter). Hence the range of mass is the cube of the range of diameters. For the previous S70 example, the range of mass would be \((0.355/0.125)^3\) or 22.9 to 1! Mass ranges would be only 2.8 to 1 for S110, 2.9 to 1 for S170 and 1.7 to 1 for S230 respectively. If the shot manufacturer needed to produce smaller shot than S70 then the lower end of the S70 grade range could be reduced to 0.180mm which would still satisfy J444. The mass range would then be reduced to 7.7 to 1 for the finer-screened S70.

**SIZE SPECIFICATION TESTING**

A typical size specification test involves taking a 100g sample of a given batch, sieving it with a set of standard sieves and weighing the sieved fractions. This type of test involves several sources of variability. One is the sample itself – which has to be selected from a large batch of shot. Various techniques, such ‘splitter boxing’, have been developed to ensure that the sample is reasonably representative. Another source of variability is that if we subject the same 100g sample to repeat testing then the weights will vary – albeit slightly. A third, more significant, source of variability is that of the sieves themselves. The individual openings in a given brand-new sieve vary in size – even with the highest quality of sieves. Wear in use exacerbates the variation in opening size - as well as causing the average opening size to drift to larger values. One noteworthy
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feature is the very large numbers of particles that are present in a 100g sample – for example, about a million for 100g of S110.

Size specification gives only a limited amount of information about size variation – see fig.5. Rather more information is available for shot sieved according to AMS 2431 which has either five or four sieve sizes per grade (depending on shot size) as compared to the four or three for J444 shot.

Fig.5. J444 specification limits for S170 cast steel shot.

Actual tests on 100g samples will give different weights depending on the sample. Size variation will be greatest for the ‘worst case scenario’ (i.e., one that only just meets the specification limits). Fig.6 illustrates this worst case scenario where 10g remained on the 0.850mm, 75g on the 0.710mm, 12g on the 0.355mm sieve and 3g passed through the 0.355mm sieve.

Fig 6. ‘Worst case scenario’ for S170 sieve test.

The nominal size for S170 corresponds to a sphere diameter of 0.425mm. An important question is “What is the average size of the shot samples sieved as shown in figs.6?” The correct answer is “We do not know – there isn’t enough information.” If we assumed that the average size of shot in each of the fractions was the average of the fraction limits then we can make an estimate. On the basis of that assumption we have 3g of 0.1725mm, 12g of 0.390mm, 75g of 0.5675mm and 10g 0.780mm particles so that the average shot size is 0.352mm! That estimate comes from mass-to-volume translations. These show that the 3g fraction is 48% by number of particles, 17% for the 12g, 33% for the 75g and just 2% for the 10g fraction.

The previous estimate highlights the central problem of size assessment – **sieve size relates to diameter whereas mass is proportional to volume**.

A ‘best case scenario’ for S170 would be one of virgin shot that only had one fraction – all 100g passing the 0.710mm sieve and being caught on the 0.425mm sieve. Even then we would not know precisely the average diameter.

**INDIVIDUAL SIZE MEASUREMENT**

We can only assess size variation if we can measure individual particles. Measurement of individual particle size can be attempted in several ways. The most commonly-used methods are **precision weighing** and **image analysis**. Each method has its pros and cons. Sample size is important. A range of 10 to 1000 particles represents practical sample sizes. Less than 10 measurements are insufficient to detect variation with meaningful accuracy. More than 1000 measurements are probably too time-consuming. Weighing is independent of shape. Image analysis measurements, on the other hand, are affected by the shape of individual particles and are relatively subjective.

**Weighing**

Weight measurements are objective and accuracy can be assured for a given weighing instrument. The major drawback is that individual particles have to be manipulated onto and off a balance pan. This is facilitated by using a piece of nylon mesh to assemble the original sample (as in fig.1) and then transferring individual particles by means of a magnetic needle. Modern electronic balances can transfer mass values directly to an Excel spreadsheet.

**Image Analysis**

This requires the use of a camera microscope to obtain an image, followed by the application of an image analysis computer program. The initial problem is that programs cannot, of themselves, separate touching particles into discrete objects. As with weighing, a nylon mesh separating individual particles is therefore useful. Alternatively, images have to be ‘computer-processed’. Computer processing involves progressive ‘binary shrinking’ (peeling of particle layers until none of the particles is touching) followed by ‘binary expansion’ that artificially prevents particles from touching one another. This results in an image of the shot particles that the computer can now treat as separate objects.

The mean of either image analysis or weight measurements will yield values for **average size**.

**AVERAGE DIAMETER/MASS MONOLAYER MEASUREMENT**

In order to measure the average particle size for a sample we can, as mentioned previously, measure a known number of particles individually and take the average. An alternative approach is to measure the total mass of a sample that, as a monolayer, occupies a fixed area. This approach is based on the fact that there is a direct relationship between average particle diameter, $d$, and mass, $M$, of a monolayer of area, $A$. 

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For ‘square-packed’ spheres the number of particles, \( n \), occupying an area, \( A \), is given by \( n = A/d^2 \). The mass, \( m \), of one particle is given by \( \rho \pi d^3/6 \). The mass, \( M \), of the \( n \) particles occupying the area, \( A \), is therefore given by:

\[
M = A/d^2 \cdot \rho \pi d^3/6
\]

which simplifies to equation (1).

\[
d = 6M/A \cdot \rho \pi
\]

where \( \rho = \text{density} \).

Fig.7 serves to illustrate equation (1), using identical ‘square-packed’ spherical particles.

The principle embodied in equation (1) can be applied by spreading a shot sample over a fixed area. The sample size will normally contain a very large number of particles. 10g of S110, for example, would contain more than 100,000 particles. Imagine, as a hypothetical example, a sample of S110 shot that has an average diameter that is exactly 0.0110" and, when spread over a fixed area, has a mass of precisely 10.00g. A 1% increase in sample diameter, other things being equal, would raise the mass to 10.10g.

Such a mass change is readily detected using the scales required for standard sieve tests.

Shot particles simply poured into a circular dish do not readily form a true monolayer. Fig.8 shows a number of ‘second layer’ particles together with ‘vacant particle sites’ (black dots versus white areas). Layers equivalent to monolayers can be produced in a few seconds by equating the numbers of ‘second layer’ and ‘vacant particle sites’. Reproducibility of layer mass is then excellent – better than 0.1g for samples of about 10g. True monolayer production requires more sophisticated techniques than simple pouring. Gaging approach to true monolayer achievement is facilitated by projecting a magnified image from a digital camera onto a computer/TV screen.

SIZE VARIATION ANALYSIS

The two most useful procedures for representing size variation are:

HISTOGRAMS and BOXPLOTS.

Histograms

Histograms are based on dividing measurements into ‘bins’ – each bin containing all of the measurements that lie within a defined range. Figs.9 and 10 are histograms of ‘number of particles in a given bin for 69 weighed particles of S780 shot. The mass measurements plotted in fig.9 were converted into diameters of ‘equivalent spheres’ for plotting as fig.10.

There are pros and cons attached to the use of histograms – some of which are indicated in figs. 9 and 10. Different types of distribution result from plotting different parameters. Mass variation appears to be skewed towards lower values whereas diameter variation appears to be bi-modal. The test sample originated from shot that had been segregated (by sieving) according to diameter. It is possible that the sample is a mixture of two sievings – each being normally-distributed about a different mean. Bin size, parameter and range strongly affect implied types of distribution.

Histograms do not yield quantitative parameters of distribution. Their strongest feature is that they present a familiar type of visual image. Data acquired for histogram analysis can be used to determine complementary parameters such as range, mean and standard deviation.
Boxplots
Boxplots depict, graphically, a summary of five parameters obtained from a set of measurements. The five parameters are: Minimum value, Maximum value, Lower quartile (Q1), Median and Upper quartile (Q3). “Median” is the middle value of a set of measurements – hence half of the measurements are larger than that of the median and half are smaller. “Quartile” is a quarter of the total number of measurements. It follows that the ‘box’ contains half of the measurements whilst a quarter are ‘above’ and the remaining quarter are below the box. Excel uses its own system for determining quartiles – together with minimum, maximum and median values.

Fig. 11 shows a set of three Boxplots derived from hypothetical data using Excel. This illustrates how we can readily compare, quantitatively, the most important size parameters of shot in terms of difference.

Unlike histograms, Boxplots are completely objective in the sense that they are independent of plotting variables (such as bin size, number of bins etc.). That feature is particularly useful when it comes to possible specification considerations.

Interpretation of Boxplots gets easier with practice. This particularly applies to the very useful ‘position of median within the box’.

Fig. 11. Boxplot comparison of three hypothetical samples.

DISCUSSION AND CONCLUSIONS
This article has considered only cast steel shot – rather than the full range of types and materials that are commercially available for peening. That is in order to contain the article within a reasonable size whilst avoiding superficiality. The principles described using J444 can easily be extended to AMS 2431 shot specification.

The origin of variability lies with the casting process. Subsequent sieving operations are used to produce specified size grades. Size testing based on standard sieve tests on 100g samples yields restricted amounts of information in terms of size distribution and none on actual average size. Image analysis is now readily available and offers a way of obtaining much more detailed information. Care must be taken to ensure that the image analysis procedure used on samples gives repeatable, consistent, results.

100g samples used for sieve testing are much larger than those used for image analysis. Even greater care must therefore be taken to ensure that image analysis samples are representative.

Analysis of size variation based on either image analysis or weight measurements can be carried out using either histograms or Boxplots. It is suggested that Boxplots are much more suitable than histograms as a basis for both specifications and quality control.

It has been proposed in this article that average size measurements can be made by weighing monolayers of known area. Preliminary results are very encouraging and techniques are being developed to facilitate monolayer production.
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For Sonnimax, no task is “business as usual”. In close cooperation with Danish subcontractors within steel and coating industries, we have pointed out large savings for our clients. Particularly for customers in the Danish windmill industry and the steel shipyards, our expertise has provided large financial advantages. We are continually working on transferring these good results to other types of industries.

Wheelblasting has always been a core element for Sonnimax. Even though we service many different kinds of wheelblast clients, we always help each client save money even while they increase their production flow. We have also updated machines to meet the demands of “heavy duty” production.

Our experience tells us that customers often do not think about the cost of seemingly minor problems. For instance: The airwasher is wrongly adjusted, the load (measured in amp) on the blast wheels is not equally distributed, or parts of the wheel are worn. We calculate the cost per year for a poor setup compared to the savings of our recommended setup.

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SONNIMAX HISTORY

In March 1969, Sørren Max Nielsen (“Max”) made one of the rooms in his home into an office and the story of Sonnimax began. Over the years, Max built a good reputation and strong relations with large and small clients within the Danish steel industry. After five years, Max moved his business and family to another residence closer to industry and located virtually in the middle of Denmark. “Ströigaarden” became known in the industry as the center of surface technology. During the next couple of years, Sonnimax expanded its activities and more employees entered the company. During the eighties, Sonnimax developed the largest and most diverse spare parts and abrasives stock in Denmark. In mid 2005, Max sold the company, now a public limited company, to the next generation, his son Erik. Erik had been the company sales manager for 10 years and he was ready to take Sonnimax further. As part of this process, Sonnimax moved its headquarters in 2007 to the central industrial quarter in Middelfart.

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Arshad Hafeez of PRI, which administers the Nadcap program, said: "By accepting Nadcap accreditation, Parker Aerospace Group is demonstrating its commitment to continual improvement and quality in special processes and supply chain management."

Wheelabrator celebrates 100th Anniversary at their LaGrange location
LaGrange, Georgia. Wheelabrator Group leads the worldwide surface preparation industry with 1,320 employees in 19 countries. The company recently marked its first century with the first of many global 2008 celebrations at a day-long LaGrange event for 150 local employees, company executives and civic leaders. "Today, we’re the acknowledged leader in our industry segment," Wheelabrator President and CEO Robert E. Joyce, Jr. told employees. Joyce reminded employees that Wheelabrator leadership does not afford the opportunity to rest. "We cannot be satisfied with being good because there is always room for improvement. We need to change faster than our competitors in meeting clients’ needs," said Joyce.

Georgia Congressman Lynn A. Westmoreland reminded employees and guests that Wheelabrator came into existence about the same time as the first automobile. Westmoreland praised Wheelabrator for its "great job of building a family unit that wants to work together and do great things." Gary Weil, Director of Risk Management and Technical Services for Wheelabrator Group, has been an employee of Wheelabrator for over 40 years. With such an extensive history with the company, Weil was able to give new employees an insight into the past of Wheelabrator and why the extraordinary company has been able to survive the tests of time. "Our business foundation had four primary supports that were alive and had to be fed to sustain our successes and reduce our failures: understanding the Global markets of the industries we served; understanding the raw materials and processes used by those industries; understanding what Wheelabrator Technology could and could not do; and understanding the part people play in the dynamics of truly successful selling," said Weil.

Founded in Pittsburgh, Pa. in 1908 by Verne E. Minich, Wheelabrator Group moved to LaGrange from Mishawaka, Indiana, in 1987. The company’s continued success hinges on a consistent and clear purpose. Joyce stated, "Our focus is simple—give the customers what they need—and in order to effectively do that, we must continuously remake ourselves." He continued, "Our customers are seeking solutions to lower the cost of production, as well as find products that last longer. Wheelabrator works to meet this need every day through innovative solutions."

In remembrance of the company’s 100 year celebration, Joyce presented Lukken and Westmoreland with specially commissioned Wheelabrator coins and a book, "Revolutions, The first 100 years of Wheelabrator Group." The planting of a Japanese maple tree and the burial of a time capsule, to be opened in 50 years, also marked the occasion.

Wheelabrator Group celebrates 100 year milestone as a provider of surface preparation and finishing solutions
Burlington, Ontario. Wheelabrator Group Technology Centre Canada commemorated its 100 years in business with a Luncheon Celebration at its facility on September 12, 2008. As the acknowledged market leader within the automated blast cleaning industry, Wheelabrator Group manufactures and installs standard and custom Wheelabrator® blast systems for removing millscale and rust, and for profiling surfaces to improve the performance of protective coatings. Wheelabrator Group serves a diverse range of industries: aerospace, automotive, marine, steel fabrication, die casting, foundry and medical.

On June 1, 1908, intrepid entrepreneur, Mr. Verne Minich, took possession of his first sandcutting machine in Pittsburgh, Pennsylvania. He started with a simple idea—give the customers what they need. It was from this simple idea and auspicious beginning that the company now known as Wheelabrator Group began. The Canadian division of Wheelabrator also started with a humble beginning. Wheelabrator Group Canada began as a small sales office in 1960 in Scarborough, Ontario. Since December 1999 (having moved several office locations over the years including Milton and Oakville), the Wheelabrator Group Technology Centre Canada headquarters currently sits in Burlington. The Burlington location is responsible for engineering and manufacturing the blast cleaning systems.

“We continue to always ask ourselves the same question today as we did in 1908: what will our customers need in the future? We talk to our customers in order to understand their business challenges. We develop solutions and enhance our technology to meet their ever-changing needs and we are not afraid to remake ourselves to ensure that we never become complacent”, confirms Mr. Robert E. Joyce Jr. CEO, Wheelabrator Group.

The Centennial Luncheon Celebration was hosted at its Burlington, Ontario facility. Wheelabrator invited its current employees, customers, international executives, distinguished past employees, local and provincial politicians, and local media to join in the celebration. Before the Luncheon festivities, Wheelabrator Group offered an Open House of its plant facility, showcasing their various blast cleaning machinery and technology offerings. Guest speaker, renowned Canadian Broadcast Journalist and President of John Stahl Communications, Mr. John Stahl, addressed the “Evolution of Wheelabrators Past, Present, Future “, recappping 100 years of ground-breaking highlights and consistent success. Ms. Joyce Savoline, our local MPP, was also in attendance, representing the Burlington community.

To honor all current employees, a commemorative coin was given as a keepsake for their dedication and loyalty to the organization.
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Study on the Failure Ratio of the High Carbon Cast Steel Shot

This paper was submitted by Xinhua Zhao, a graduate student at the Material Science & Engineering College of Shandong University in China. The Shandong Material Science & Engineering College extensively studies shot peening and blast cleaning and provides technology support to Shandong Kaitai Metal Abrasive Company, one of China’s largest metal abrasive producers. According to Mr. Zhao, his study on the wear failure of high carbon cast steel shot brings new concepts to the abrasive field. The complete article is available in the online library at www.shotpeener.com.

Xinhua Zhao1, Ruwei Liu1, Hongwei Wang2, Hongju Gao1, Laibin Zhang3, Ruiguo Wang3
1. College of Materials Science and Engineering, Shandong University
   Jinan 250061, P.R. China
2. Chemical Products Recovery Shop
   Laiwu Steel Corporation
   Laiwu 271104, P.R. China
3. Shandong Kaitai Metal Abrasive Co., Ltd.
   Zouping 256217, P.R. China

Abstract
The ERVIN test machine was used in this study to mimic the actual blast cleaning process. The high carbon cast steel shot sample, heat-treated at five different temperatures, are put into a ERVIN tester and ran for predefined cycles. The wearing of the samples were examined under a magnifier. The failure ratio was defined and its influencing factors were studied. The results show that the failure modes, including brittle fracture, surface peeling and core spall, can be analyzed by means of failure ratio represented by the defined weight ratio Gf/Gt, the failure ratio are affected by the heat treatment, ERVIN cycle, microstructure and flaws, particle size, target hardness. Impact velocity and impact angle play an important role in the wearing failure process.

Keywords: high carbon cast steel shot, failure ratio, surface peeling; core spall, weight ratio, influencing factors

1. Introduction
From the appearance, it is difficult to distinguish the high carbon cast steel shot samples after different heat treatments, and at present the abrasive manufacturers only provide the technical data and physical characteristics in the data sheet based on related standards[1,2], but the ERVIN life and the wearing failure modes are not given enough importance, hence the author suggests that ERVIN life, the main failure mode and its wearing ratio should be added to the data sheet, which can complete the abrasive standard, provide convenience for the end users to choose the suitable abrasive, encourage the manufacturers to improve their manufacturing process and improve the abrasive quality. But the failure ratio is affected by many factors so that it is necessary to evaluate the failure ratio under the same condition.

2. Samples and the Processing Procedure
The as-cast high carbon cast steel shot sample used in this experiment, manufactured by Shandong Kaitai Metal Abrasive Co., as shown in Table 1, was melted by medium frequency induction furnace and formed by centrifugal atomizing method. The samples were in good spherical shape without irregular forms and cracks. The box resistor stove was used as the heating device and water was used as the cooling medium. The samples were etched by the alcohol solution with 4% of nitric acid and then studied for the microstructures using a metallograph. The micro hardness of the samples were tested by the vickers hardness tester with a 500g load. As shown in Table 1 and Table 2, five high carbon cast steel shot samples, undergone five various heat treatments, were prepared for this study; the samples, tempered at 150°C and 550°C and double quenched at 840°C, were run in ERVIN test machine for 500 cycles, 1000 cycles and 1500 cycles respectively. 20g samples were used in each run for clear observation of the wear failure morphology and hence easy assessment of the failure ratio,
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Outstanding Papers from ICSP-10

It all started in 1980 when Abbas Niku-Lari convened a meeting in Las Vegas to organize the first International Conference on Shot Peening in Paris. Close to 400 delegates attended from around the world to explore the opportunities to advance the science of peening. What evolved from that farsighted effort are tri-annual conferences held around the globe and tremendous research and development in the shot peening industry.

The most recent conference held in Tokyo continued the tradition of sharing information on innovations and adaptations in the war against metal fatigue. There were 91 papers presented in Tokyo at ICSP-10 which brings the total number of conference papers to 640. That's pretty impressive for an industry that's relatively unknown by many academics and industrial engineers and often referred to as the stepchild of the abrasive blast cleaning industry.

The following are just a few of my favorite papers from the conference.

**Butt Joining of Sheet by Shot Peening**
Y. Harada, K. Fukaura, A Yamamoto, S. Ujihashi, Y. Kobayashi

This article illustrated a novel concept of joining dissimilar sheets with high tensile strength by peening the surfaces of notched edges. This technology can be used in applications where welding is not feasible or desirable.

**A Novel 3D Finite Element Simulation Model for the Prediction of the Residual Stress State after Shot Peening**
M. Zimmermann, V. Schulze, H.U. Baron, D. Lohe

The paper takes into account component thickness when performing Finite Element analysis. It was found that a small thickness has no influence on the residual stresses present in the surface region but great influence on the tensile residual stresses present in deeper regions. The new approach of model constraint takes into account deflection effects and yields to a very good accordance with experimental results.

**A Scaling Law in Shot Peening Induced Surface Material Property Deviations**
A.M. Frishman, C.C. H. Lo, Y. Shen, N. Nakagawa

“A Scaling Law in Shot Peening...” shows examples of several material property deviations under varying Almen intensities and validates the predicted scaling relations against experimental data. This tool should be able to predict residual stress profiles at varying Almen intensities. The scaling law is also found useful in assuring consistency among nondestructive characterization measurements.

**Development of Fe-Based Metallic Glass Shot Amo-Beads for Peening with High Strength and Long Life**
K. Okumura, K. Kajita, J. Kurotsuki, H. Kimuar, A. Inoue

Spheroidal particles made with the Fe-base metallic glass were used as shot for peening and it was proved that this is of high hardness together with long-life. This new product, introduced as AMO-Beads, was the result of intensive research led by Inoue and the Institute of Material Research of Tohoku University when they discovered a number of alloys with high Glass Forming Ability (GFA).

**Fatigue Property Enhancement by Fine Particle Shot Peening for Aircraft Aluminum Parts**
A. Inoue, T. Sekigawa, K. Oguri

Fine particle shot peening (FPSP), popular in the Japanese auto industry for many years, is now applied to aerospace applications and tests reveal that FPSP can offer superior fatigue life to conventional shot peening. Fatigue cracks appear at the subsurface layer as compared to conventional shot peening where the cracks originate at the surface due to small flaws and laps on the surface created by the conventional shot peening process.

These papers were of interest to me for many reasons. Some covered research that may benefit EI, some covered subjects that I’ve been interested in for years, some covered novel, exciting concepts. There were papers presented at ICSP-10 that will be of value to you, too. The Conference Proceedings, edited by Dr. Katsui Tosha of Meiji University and Dr. Yoshihiro Watanabe with Toyo Seiko, will be available for purchase at the Toyo Seiko web site (www.toyoseiko.co.jp) and at www.shotpeener.com for $125.00 (65 euro), plus shipping. I encourage you to take advantage of the wealth of information that has been made available, thanks to The International Conference on Shot Peening.
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