Winter 2012
Volume 26, Issue 1 | ISSN 1069-2010

The Shot Peener

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

Car Manufacturers Need to Lighten Up

Component Shape Changes Caused by Shot Peening
by Dr. David Kirk

2011 Shot Peener of the Year

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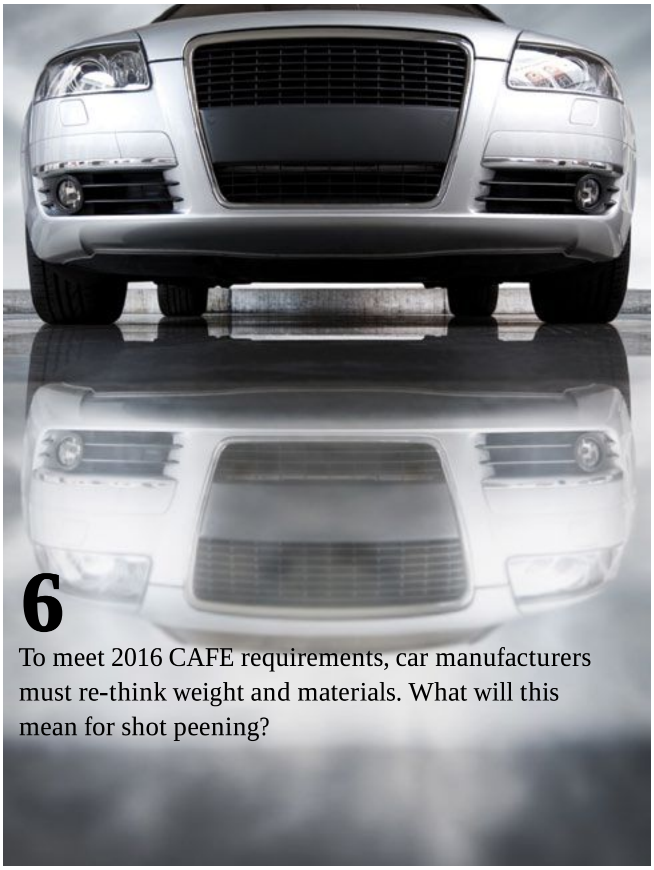

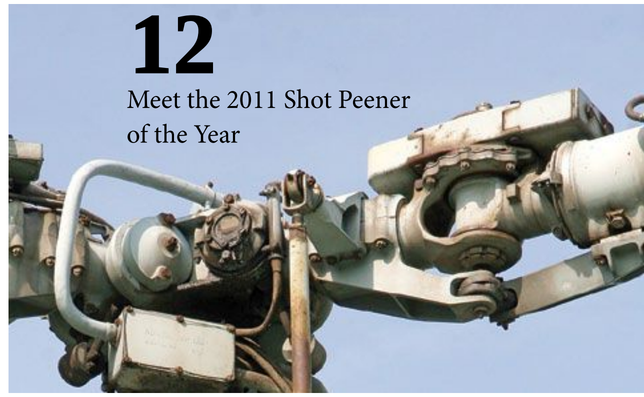

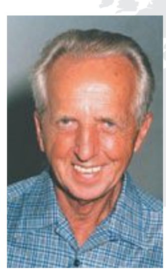

THE SHOT PEENER
Sharing Information and Expanding Global Markets for Shot Peening and Blast Cleaning Industries

Always Striving, Always Growing

I HAVE ENJOYED watching the evolution of *The Shot Peener*—from the first publication (it was actually a two-page letter) in 1986 that was sent to less than 100 people—to its newest magazine format that will have at least 6,500 readers. This will be the first issue that will be distributed in print and electronic format. Students especially want a digital version and we trust that the magazine will go viral through engineering programs in universities around the world, as well as many other online venues.

We hope you like the magazine's new look. The magazine's makeover even extended to me...I was told it was time for a new photo. You'll discover that the magazine's changes aren't just cosmetic. *The Shot Peener* will continue to provide solid information on the who, what, when and where of the shot peening industry, but we're expanding our mission to provide insights and inspiration within our small niche and in the larger world of related manufacturing topics and technology.

JACK CHAMPAIGNE
Editor

An underlying theme in this issue is how to stay current and even benefit from the rapid changes that are being forced on us through government regulations, new materials and innovation. Successful marketing strategies have come a long way from a two-page typed newsletter on shot peening.

In one of those strange twists of fate, Dr. Kirk's article in this magazine has more value than ever to me. I've been working with a company that has been wrestling with distortion as a result of blast cleaning and here was the ideal article to explain shape changes from shot peening.

"Component shape changes are always a consequence of shot peening. These changes may be desirable, undesirable or so small that they can be ignored. Desirable shape changes can be generalized as either 'peen-forming' or 'distortion rectification' whereas undesirable shape changes can be generalized as 'distortion'."

—Dr. David Kirk

The Shot Peener staff and I want you to benefit from the articles in the magazine, too. That's our purpose, that's why we're always striving to be better. Here are my best wishes for your professional and personal growth and success in 2012.

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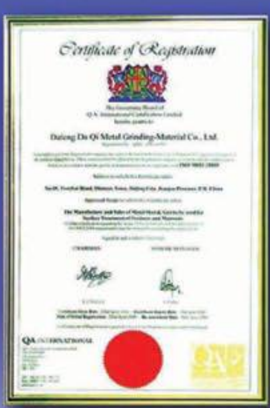

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Unbearable lightness?

To make cars frugal, they will have to become lighter—and more expensive

WHEN IT COMES to motor vehicles there is widespread belief—at least in America—that bigger is not only better, but safer too. The assumption is that nothing beats having lots of steel around you in a crash. And it is true, to some extent. All things being equal, the driver of a large SUV (sports-utility vehicle) is less likely to be killed than the driver of a small car in a head-on collision between the two. The downside is that SUV drivers are far more likely than car drivers to die in solitary roll-over accidents induced by the vehicle's own weight, its high centre of gravity and its truck-like suspension. Collisions with other SUVs can be deadlier still.

An excess of heavy metal imposes other penalties. American motorists are as aware as any that weight is the enemy of fuel economy. However, with pump prices low by international standards, the trade-off between safety and fuel consumption has understandably favoured the former. Adding air-bags, anti-lock brakes, stability control and side-impact beams has saved countless lives, but it has increased vehicle weights disproportionately. Cars and light trucks on American roads today are 30% heavier than they were in the mid-1980s.

Unfortunately, heavier vehicles need beefier engines to lug their extra girth around. As a result, much of the past quarter-century's improvements in engine and vehicle design—low-friction materials, turbo charging, direct injection, variable valve-timing, cylinder deactivation, stop-start ignition, dual-clutch transmissions, better aerodynamics and low rolling-resistance tires—have been mopped up by increases in vehicle weight.

It therefore comes as no surprise that the pronouncement by the White House—that cars and trucks sold in America from the 2016 model year onwards will have to achieve a fleet-wide average of 35.5mpg (6.6 litres/100km)—should have awoken fears about vehicles becoming smaller and less safe in order to meet the latest fuel-sipping standards. The new corporate-average fuel economy (CAFE) figure, originally

scheduled for 2020 but brought four years forward by the Obama administration, amounts to a 34% increase over today's actual average of 26.4mpg.

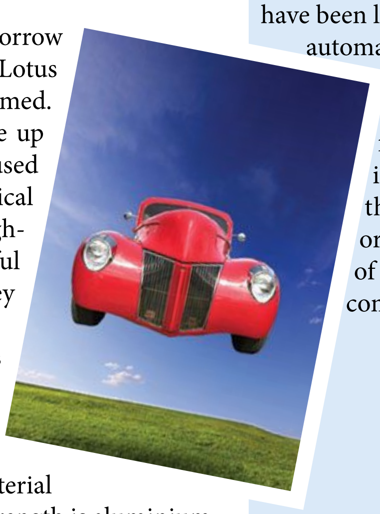
How to achieve such a whopping increase in efficiency over so short a time? The trouble is that most of the low-hanging fruit in combustion engineering have been picked already. At best, the motor industry expects only a 15-20% further improvement can be squeezed from existing petrol engines and their transmissions. A new generation of plug-in hybrids and pure electric vehicles will doubtless help achieve the required goal. But even if their sales triple over the next five years, they will still account for less than 10% of America's fleet of new cars by 2016.

Though themselves not cheap, clean diesels, with their 35% greater efficiency, would be a better bet—if only Americans could be persuaded to embrace them as Europeans have. Although no longer justified, the diesel's reputation for being slow, smelly, noisy, unreliable and difficult to start in cold weather has lingered since the 1980s, when Detroit rushed out half-baked designs in response to the oil crisis. But even if the demand for diesel cars were there, the fuel might not be—at least, not at a price Americans would be willing to pay. As it is, there is already a global shortage of diesel-making capacity. The catalytic crackers used in refineries throughout America are optimised to produce as much petrol as possible. Switching them over to the hydrocracking processes used widely in Europe and Asia for diesel production would take donkey's years.

So it comes down to this: if half the increase in efficiency demanded by the new CAFE requirements is to come from further improvements in the power-train, then the other half will have to come from reductions in a vehicle's weight. That prompts two immediate questions: how much will such a weight reduction add to prices, and will hard-won gains in vehicle safety be sacrificed in the process?

Given today's materials and know-how, automotive engineers reckon a 10% reduction in vehicle weight yields a 6% improvement in efficiency. Meanwhile, trimming the fat from a vehicle's bodywork, components and accessories costs roughly $2 a pound. Running the numbers for a typical car—say, a Toyota Camry weighing 3,260lb (1,500kg) and averaging 26mpg—suggests it would need to shed a little under a third of its weight, at a cost of roughly $2,000, to meet the 2016 standard. The Environment Protection Agency claims average prices on the forecourt will rise by only $1,300. Someone, somewhere, seems to have got their sums wrong.

In the end, the additional price for "adding lightness"—to borrow a phrase from the late Colin Chapman, the legendary founder of Lotus Cars—comes down to the materials used and how they are formed. To do the same job, HSLA (high-strength low-alloy) steels are up to 30% lighter than traditional carbon steels. They are already used in motor vehicles for components that have to withstand critical loads. Unfortunately, because of their higher strength and toughness, HSLA steels need 30% more energy to form them into useful shapes. Also, because their strength tends to be directional, they can fail under sudden loads from unexpected quarters.



One of the ways that Chapman added lightness to his cars, the use of composite materials such as carbon fibre and glass-reinforced plastic, is not that practical either. Lotuses are turned out in small numbers, but composites require too much manual work for volume production. So the only sensible material for reducing a conventional car's weight while maintaining its strength is aluminium.

At present, aluminium accounts for 9% of a typical vehicle's content—mostly in the form of castings and forgings for engine blocks, transmission cases, wheels and suspension parts. For the aluminium content to increase much further means using

MARKETING INSIGHT

Alcoa is Ramping Up to Meet Demand

DES MOINES, Iowa (Associated Press). Alcoa Inc. announced in September 2011 that it will invest $300 million to expand and add 150 jobs to its Davenport, Iowa plant.

Alcoa Vice President and General Manager John Fox said demand for aluminum products produced by Alcoa is growing with the new automotive guidelines.

"It allows for a smaller power train, better mileage and less CO2 output," Fox said. "It means our business is growing quite well."

"All the major manufacturers continue to express interest in moving to aluminum, with that movement that means we can bring more people to work," Fox said.

The expansion will also help retain 200 jobs Fox said would otherwise have been lost. He said with the automakers required to increase mileage by 2016, the company needed to move forward with the project immediately. Fox added that equipment has been ordered and the expansion of the plant is expected to be completed by the end of 2013.

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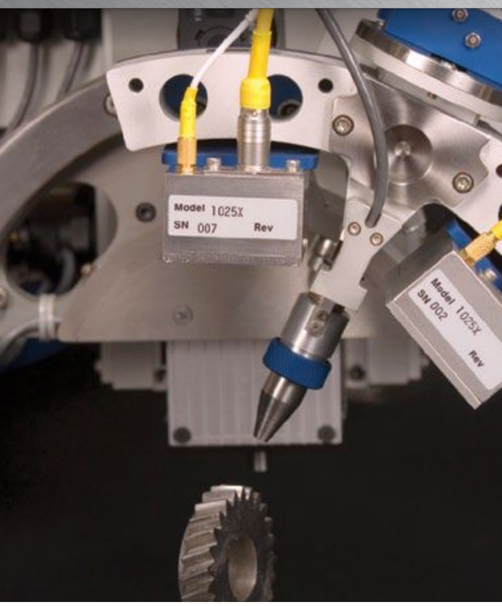

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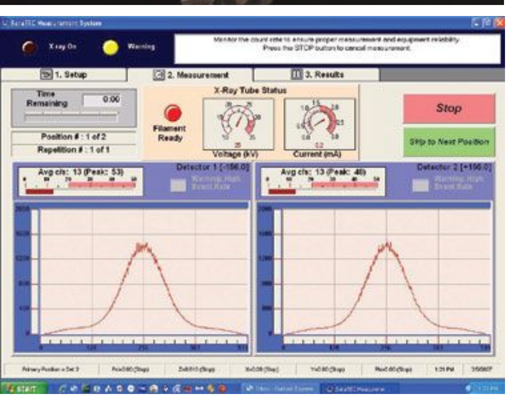

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Materials Testing Division • 10737 Lexington Drive • Knoxville, TN 37932 USA sheets and extrusions of the stuff for body panels and subframes. That will require further advances in laser welding and other bonding techniques to make production costs competitive.

The handful of aluminium-bodied cars in production have mostly been low-volume luxury models, such as the Honda NSX, the Audi A8 and the Jaguar XJ. Their body weights have typically been 10% to 15% lower than those of their steel equivalents. However, if all the parts made of iron and steel in cars today were replaced with aluminium, the vehicle would weigh 45% less. And it would be stronger, too. Pound for pound, aluminium is up to two-and-a-half times stronger than conventional steel—and can absorb twice the energy in a crash.

In short, making vehicles lighter does not mean they have to be smaller or less safe. If anything, cars with a high aluminium content have tended to be bigger and stronger than their steel-bodied predecessors. Replacing steel with aluminium allows additional interior space to be offered, along with larger crumple zones at the front and rear for even better crash protection, all without paying a heavy penalty in fuel consumption.

But there is a snag: cost. Aluminium is three to four times more expensive than steel. On the plus side, aluminium cars do not rust, and therefore last longer than conventional cars. And, at the end of their lives, they have a much higher scrap value. Add in the fuel saving, and the lifetime cost of an aluminium car—from raw material and manufacturing to daily use and final disposal—can be comparable to that of a conventional car. And the higher petrol prices go, of course, the sooner an aluminium car becomes as cheap overall as a conventional one.

The stumbling block in this analysis is that the person who walks into a showroom to buy a brand new aluminium car is unlikely to capture all those lifetime benefits. Nor is the manufacturer—at least, not immediately. So expect the initial sticker prices to be at least $2,000 higher for enlightened compact cars, and $4,500-6,000 more for trimmer luxury cars and SUVs. The only consolation will be not having to fill up the tank quite so often.

Metal Improvement Company Responds to CAFE Requirements

Engineers at General Motors are credited with developing shot peening as a production process in the 1930s. Shot peening was initially applied to valve springs, then to gears and connecting rods, then to many other steel automotive components. Metal Improvement Company believes that the automotive industry, like aerospace, will further evolve and begin to incorporate higher-strength steels and aluminum to reduce weight and subsequently improve fuel efficiencies. These metal alloys, however, tend to be more brittle and vulnerable to fatigue cracking and stress corrosion-related failures than conventional steel, and shot peening will be called upon to provide protection.

An automobile has hundreds of components embedded into many sub-systems. Most of these components have already been continually optimized for decades, thus making it hard to find obvious and easily obtainable solutions to the pending Corporate Average Fuel Economy (CAFE) requirements. An indirect benefit of these improvements, which isn't recognized in the CAFE requirements, is the ability of new vehicles to last 150,000-300,000 miles, thereby reducing the need to replace vehicles as frequently as in the past. Car owners that keep their vehicles longer present a significant reduction in energy usage due to reduced new vehicle production.

"Throughout the vehicle, it's the many incremental savings, like those achieved with shot peening, that will gradually move our current vehicle fleet towards the new CAFE requirements."

—Jim Harrison
Marketing Manager
Metal Improvement Company

While today's vehicles last longer, they have gotten significantly heavier. Compact cars sold in the U.S. today on average weigh 549 pounds more than those sold in the States a decade ago according to an edmunds.com analysis. The weight gain is a major challenge in meeting CAFE requirements.

Shot peening fits into the solution through its ability to incrementally improve the power density of metal components. For example, if replacing a steel component with an aluminum component yields a 30% weight savings, additional weight savings are possible with shot peening, depending on the failure mode and application. Throughout the vehicle, it's the many incremental savings, like those achieved with shot peening, that will gradually move our current vehicle fleet towards the new CAFE requirements.

Metal Improvement Company is already working closely with its automotive customers to develop shot peening specification callouts that enable the use of these materials to their best advantage.

James Kernan Named 2011 Shot Peener of the Year

James Kernan with his Shot Peener of the Year plaque. James was given the award by Jack Champaigne (right) at the U.S. Shot Peening workshop in Orlando.

"James was awarded the 2011 Shot Peener of the Year from The Shot Peener magazine due to his extensive efforts to revise SAE shot peening documents and his dedication to improving shot peening practices at Corpus Christi Army Depot and the U.S. Army Aviation and Missile Research, Development and Engineering Center."

We especially admire the tenacity and thoroughness James demonstrates while working on the "J" and AMS documents."

—Jack Champaigne
Editor, *The Shot Peener*

JAMES KERNAN is an Aerospace Engineer employed by the U.S. Army Aviation and Missile Research, Development and Engineering Center in Huntsville, Alabama. James is responsible for the maintenance engineering of helicopter drive systems, including the transmission, gearboxes and rotor head, and the repair and overhaul of drive system components. James utilizes the full spectrum of repair development including failure analysis, root cause evaluation, and design redevelopment.

James has a B.S. degree in Metallurgical and Materials Engineering from the University of Texas at El Paso and has achieved Electronics Inc. Education Division's Shot Peening Level III certification status. He is a member of ASM International and the Minerals, Metals and Materials Society.

James was instrumental in leading the Corpus Christi Army Depot to Nadcap accreditation in 2007. James realized from this in-depth audit that the shot peening specifications needed adjustments. He became a member of both the SAE Surface Enhancement Committee and the AMS Aerospace Metals and Engineering Committee (AMEC) Surface Enhancement Subcommittee. He co-authored the AMS 2590, Rotary Flap Peening of Metal Parts and AMS 2592 Flap Assemblies, Rotary Flap Peening. These specifications are utilized for minor repairs of previously shot-peened surfaces.

"I enjoy using shot peening to repair components. Through my involvement with SAE, AMEC and my field experience, I can help refine specifications that will further improve the repair processes," said James.

James is the sponsor of AMS 2430S, Shot Peening, Automatic and is responsible for coordinating its revisions. "I enjoy being part of the specification revision team and bringing together the committee members' concerns to evolve a workable, auditable requirement into the specification. I hope to see the AMS 2430 get AMS B Committee approval soon with the AMS 2432, Shot Peening, Computer Monitored revision following thereafter," said James.

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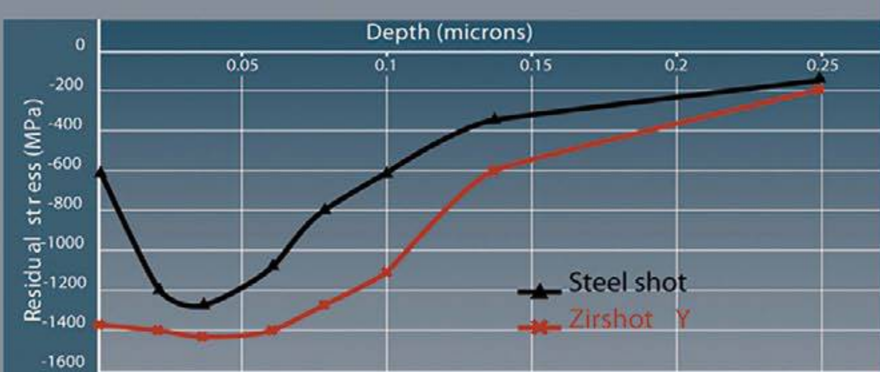

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Dan Dickey | Innovative Peening Systems

PRECISION PEENING OR SPRAY AND PRAY?

IN MY FIFTEEN years as a shot peening machine manufacturer, I have seen machines with multiple nozzles installed in facilities around the world. Many of these machines were purchased with extra nozzles so they could peen a wide range of parts. A few of these machine probably have operators that are guilty of the "spray and pray" approach to shot peening: Spray a lot of shot at the part and hope that it's peened to the proper intensity.

In a typical multi-nozzle machine setup, the part moves through the peening zone and is peened from many different angles. There can be several problems with this approach, including:

- Lack of intensity verification
- Inadequate intensity
- Wasted shot, energy consumption and operator time
- Unnecessary wear and tear on machine due to excessive shot blast
- Troubleshooting difficulties

MULTIPLE NOZZLES = MULTIPLE INTENSITY ISSUES

The angle of the nozzle is critical to the intensity value and therefore it makes sense to provide a saturation curve for every nozzle. If the movement of the nozzle is changed, more intensity verification (and coverage inspection) are required.* Establishing and maintaining proper intensity for each nozzle in these cases is a great deal of work.

WASTE, WASTE, WASTE

Consider the cost of operating an eight-nozzle machine. One 3/8-inch nozzle at 60 pounds of air pressure requires 125 cfm of air. 125 cfm of air requires a 25 hp air compressor. Now consider how much air it takes to run this eight-nozzle machine: Over 1000 cfm and 200 hp! That's a lot of power and set-up time.

If a smaller part is placed in the machine and the nozzles' parameters weren't changed, some of the shot may not even hit the part because they were pointed at a larger part. When you add the expense of wasted shot to the additional wear on the equipment's cabinetry, the cost can be substantial over the normal lifespan of a machine.

COMPOUNDED TROUBLE

Another problem with multiple nozzle machines is the complexity of the shot delivery system. If the machine isn't peening properly, where is the problem? In an eight-nozzle machine, the problem could be in any one of the 32 valves needed to run the system. Troubleshooting time needs to be added to the machine's operating expense.

THE SOLUTION IS PRECISION PEENING

So what can be done? Let's consider replacing all of this cost in consumables, power and labor with an automated single-nozzle machine.

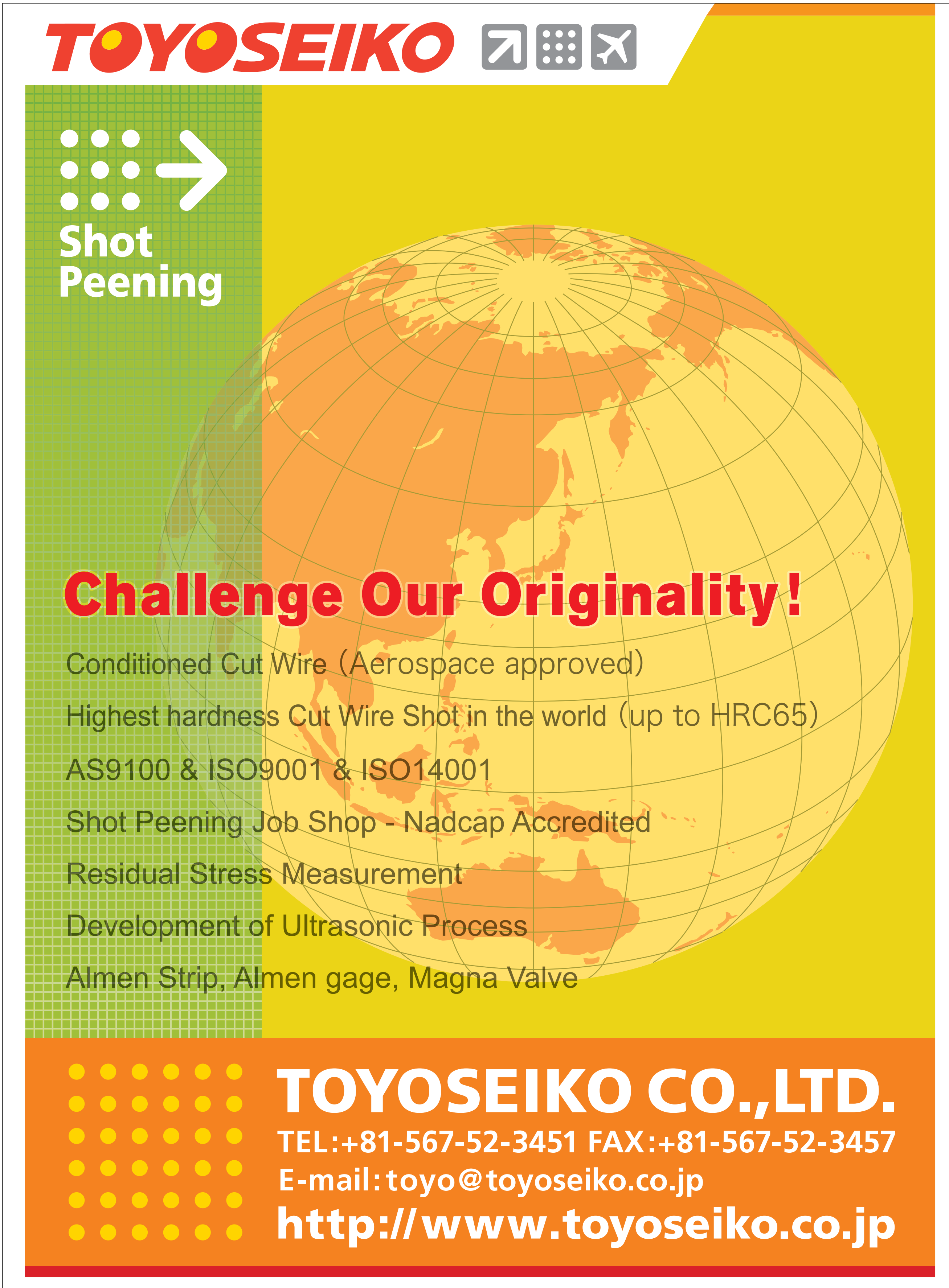
The initial cost of a robotic shot peen machine can be high but it's generally a one-time cost. When compared to large air compressor equipment and the continual labor costs associated with machine setup times, it can pay for itself very fast. Plus, the price of electronics continues to go down, making automation affordable even for small companies.

My approach is to take a single nozzle, automate the movement of the nozzle with a coordinated axis movement so the nozzle follows the contour of the area to be peened. This approach allows the shot peening technician to hit only the areas required. A part-motion recipe is developed and saved for each part, thus eliminating costly setup time.

Only one saturation curve is needed for the single nozzle. In an accurate motion program, all of the shot will strike the part at the proper angle allowing for proper intensity and coverage. Another benefit to automation is the ability to peen at the highest specification level thus providing a more valuable service to customers.

When purchasing single-nozzle automated machinery, consider how many axes are needed to move the nozzle and part(s) to achieve the proper angle to peen all surfaces. The controller is another key purchasing decision. Buying a name brand is a wise choice. Custom PC-based programs may be inexpensive but they can be hard to understand and troubleshoot by anyone but the software developer—and a small software developer may not be available when you need them. The whole point of going to a single nozzle system is to obtain a precise, yet simplified, peening process.

*For an in-depth explanation of how the nozzle's angle affects intensity, see Dr. David Kirk's article, "Variability of a Shot Stream's Measured Intensity," in the Summer 2012 issue of *The Shot Peener.*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Coverage Determination on HSLA 4340 Steel

How can I determine the coverage on HSLA 4340M steel? Is there a coefficient to relate the coverage of the Almen strip to the coverage of HSLA 4340M steel?

My name is Willem Hamer and I just started as an engineer at KLM Royal Dutch Airlines. I am doing an experimental research on how the different processing steps of HSLA 4340M steel are affecting the Barkhausen Noise Analysis. One of the processing steps is shot peening, which I am doing together with Marcel van Wonderen. During the first set of shot peen experiments I encountered that it is very hard to determine the coverage on HSLA 4340M steel. I tried to get an indication of the coverage by eye and by microscope, but both did not really work.

Could someone give me some advice about how I can determine the coverage on HSLA steel or how I can relate the Almen strip coverage with the coverage of HSLA steel? Or is it common to use the coverage of the Almen strips as indication for HSLA 4340M steel (which in theory is not very accurate due to the different sizes of indent area)?

Stemo Jayson • Hi Willem. Without going down the theoretical/academic road—when peening to the standard aerospace shot peening standard of AMS 2430, one can evaluate coverage primarily by the 10x method or by Peenscan.

The 10x method consist of looking at the dimpling under 10 times magnification. Once the surface is completely dimpled, the part has complete (100%) coverage.

The other method, using Peenscan, consists of placing a florescent die onto the part. Once the Peenscan is dry, it will be peened away. If it is completely gone, one would have 100% coverage. This is verified by looking at the part under a black light.

Walter Beach • This is a known problem throughout the peening industry so don't feel bad. We are working to address this in AMS 2430 and SAE J2277.

You will at a minimum have to use magnification higher than 10x, I would suggest 30x.

Tracer dye is a good tool of seeing if you are peening the entire part but there really is no substitute for visual inspection. On a hard material a somewhat larger diameter of tracer is removed then the diameter of the peening media itself. Because of this, complete removal of the tracer does not mean you have full coverage. I would suggest you establish your saturation curve(s) then examine the test strips for coverage at the saturation point, generally they will not quite be 100% covered at this point nor should they be. Now walk up your peening time to establish 100% on the test strips. Once done, then peen the part to double that time and inspect at 30x for full coverage you should be there or at least very close.

Jack Champaigne • Peening tracer is a good tool for targeting but you must be very careful if you rely upon it for degree of coverage. In our classes we teach the rule that if the tracer is gone the you must have a dent (needs to be verified) and also if you have a dent then the tracer must be gone. Peening tracer has a laquer type of composition which hardens on the surface upon drying. You fracture this laquer and it gets removed from the surface. A large amount of broken media in the machine can result in scratching the surface and removing tracer but not leaving the dents you expected to get.

You should consider making some test coupons of same material as your target and then submit them to your blast stream to ascertain proper blast exposure time. If you have a test fixture fitted with Almen blocks then you might make your test coupons the same size as standard Almen strips and attach them to your fixture. This is nice since you can learn the coverage performance at various locations on your fixture. You might discover that the time required to get the slowest developing strip covered that the earliest strip receives very high coverage, perhaps 200% or even higher. This may, or many not, be detrimental depending upon the characteristics of your target material.

Erland Nordin • You might measure the surface with a confocal microscope which will get you a 3D image of the surface and where the height deflection is magnified so the topography is more easy to see. You can't measure the whole surface though. It must be samples at chosen points.

"The discussion at The Shot Peening World is very interesting and as a new graduate, LinkedIn and the discussion groups are a perfect way to learn about this process and meet new people who are passionate about their profession."

Willem Hamer
Engineer, Royal Dutch Airlines KLM


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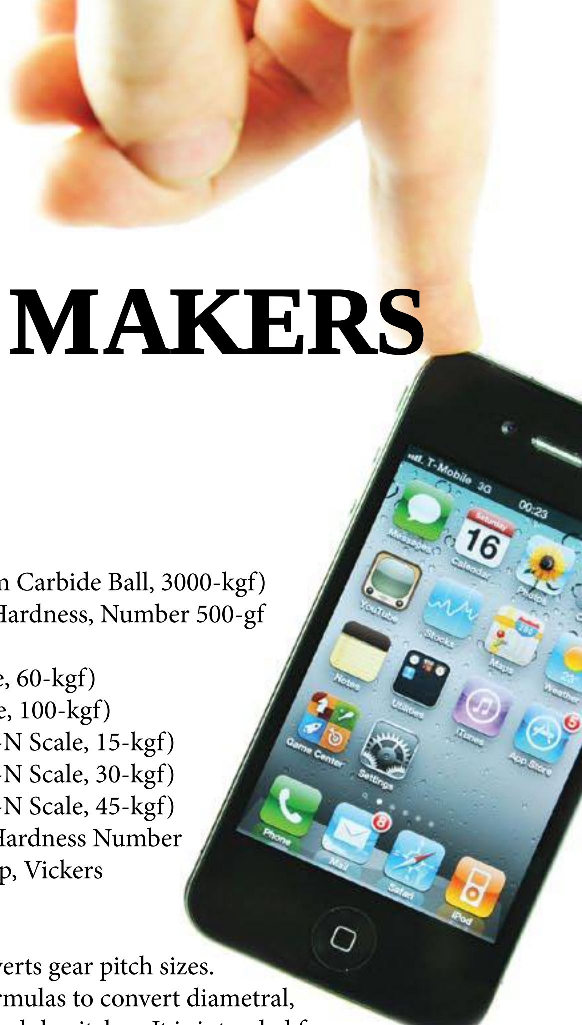


APPS FOR GEAR MAKERS

IndianaGear provides a wide range of open gearing capabilities, from mining gearing to production runs of CBN-ground transmission gears. The company recently added a 33,000 sq. ft. precision grinding center with the capacity to grind external and internal gears with diameters up to 4,000 mm and face-width gears up to 1,750 mm. IndianaGear also has an in-house shot peening process that was initially developed to eliminate shipping costs to an outside job shop, but their shot peening services are now perceived as an attractive benefit by customers.

Not content to grow only in physical size, IndianaGear is meshing gear manufacturing with wireless technology. Joel Neidig, Engineer with ITAMCO, the parent company of IndianaGear, has developed Smartphone calculator and conversion apps for gear makers. According to Mr. Neidig, he developed the apps as another way for manufacturers to use technology to be more efficient.

The Smartphone apps are also a smart marketing tool for the company. Despite their development costs, ITAMCO makes the apps available at no charge. "We've had over 30,000 downloads of our Apps in 88 countries since their release dates throughout 2010 and 2011. That's an average of 100 downloads a day," said Mr. Neidig. "Reaching customers and suppliers on a global scale has been a significant benefit. The availability of the apps in iTunes and Android Market has enabled us to reach potential customers that we might not have reached otherwise."

The following is a brief description of the apps. Again, they are free and are available for download from iTunes and Android Market. Compatibility:

- iPhone, iPod touch, and iPad—requires iOS 3.0 or later
- Android 1.6 and up

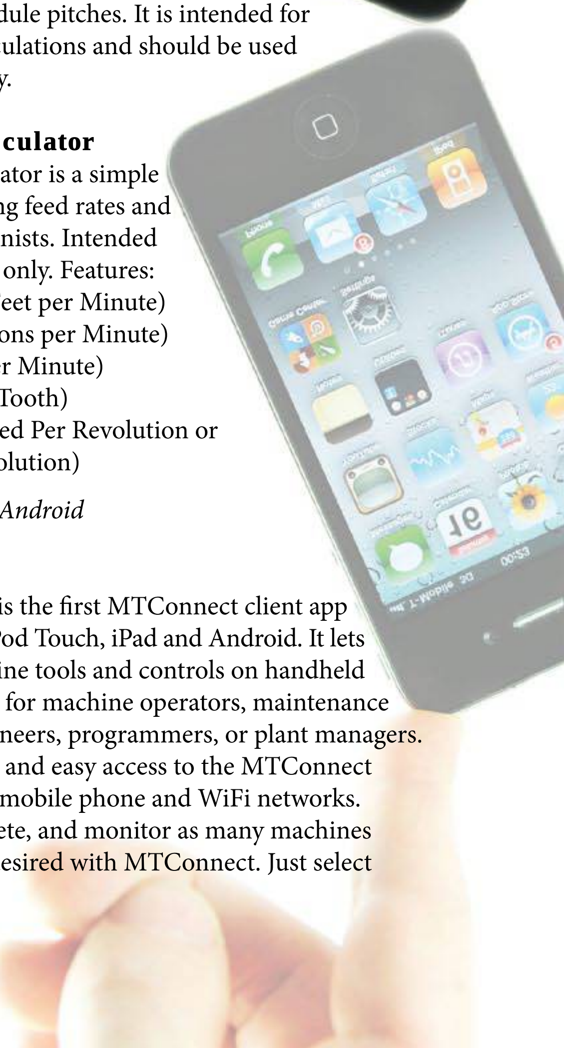
Hardness Converter

Hardness Converter is a simple app for converting between popular scales used to measure the hardness of non-austenitic steels. It is in conformance to ASTM E140-07. Converts between popular Rockwell, Vickers and Knoop hardness scales. Available scales:

- HRC (Rockwell C Hardness Number 150 kgf)
- HV (Vickers Hardness Number)
- HBS (10-mm Standard Ball, 3000-kgf)
- HBW (10-mm Carbide Ball, 3000-kgf)
- HK (Knoop Hardness, Number 500-gf and Over)
- HRA (A Scale, 60-kgf)
- HRD (D Scale, 100-kgf)
- HR 15-N (15-N Scale, 15-kgf)
- HR 30-N (30-N Scale, 30-kgf)
- HR 45-N (45-N Scale, 45-kgf)
- Scleroscope Hardness Number
- Brinell, Knoop, Vickers

GearWare

GearWare converts gear pitch sizes. It uses basic formulas to convert diametral, circular, and module pitches. It is intended for approximate calculations and should be used for reference only.



Feed Rate Calculator

Feed Rate Calculator is a simple app for calculating feed rates and speeds for machinists. Intended for reference use only. Features:

- SFM (Surface Feet per Minute)
- RPM (Revolutions per Minute)
- IPM (Inches Per Minute)
- FPT (Feed Per Tooth)
- FPR or IPR (Feed Per Revolution or Inches Per Revolution)

Coming soon for Android

MTConnect*

This application is the first MTConnect client app for the iPhone, iPod Touch, iPad and Android. It lets users view machine tools and controls on handheld devices. It's great for machine operators, maintenance technicians, engineers, programmers, or plant managers. It provides quick and easy access to the MTConnect Agent over both mobile phone and WiFi networks. You can add, delete, and monitor as many machines and controls as desired with MTConnect. Just select

the desired device after entering the http://DNS or ip address and touch the "Current" button in the top right hand side of the screen and view in real time your machine or control. Host connection must be MTConnect compatible (requires MTConnect Agent and, if needed, MTConnect Adapter).

Metal Weight Calculator
Metal Weight Calculator is a simple app for calculating weights of different types of metals in various shapes. Intended for reference use only. Materials featured: Steel, aluminum, cast iron, nickel, copper, and more. Shapes featured: Round, sheet, tube, rectangle, and more.

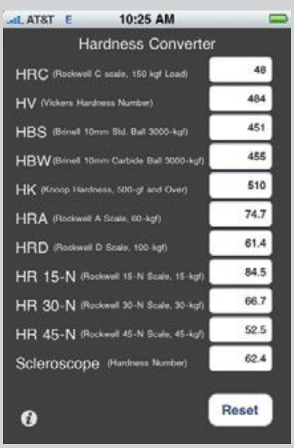
Thermal Expansion Calculator
Thermal Expansion Calculator is a simple app for calculating changes in dimensions or the thermal expansion coefficient of a substance related to its thermodynamic property when heated and expanding or contracting when cooled. Features over 100 different types of materials including iron, nickel, silver, gold, copper, and more.

Coming soon for Android

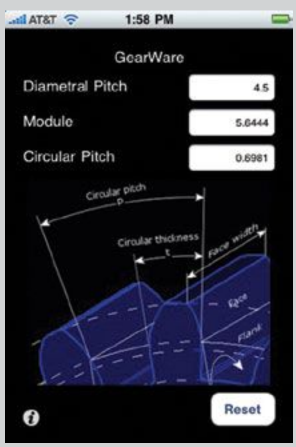
* What is MTConnect?

MTConnect is a set of open, royalty-free standards intended to foster greater interoperability between controls, devices and software applications by publishing data over networks using the Internet Protocol.

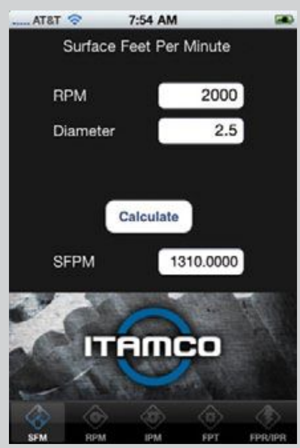
SCREEN SHOTS



Hardness Converter



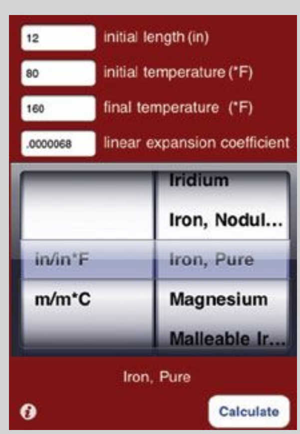
GearWare



Feed Rate Calculator

MTConnect

Metal Weight Calculator



Thermal Expansion Calculator

Uh, not really.

While manufacturing apps, like those from ITAMCO, are quickly becoming trusted resources on the plant floor, ***games*** continue to be the most popular app category. And, according to Nielsen research, 93 percent of app downloaders — those who have downloaded an app within the past 30 days — are willing to pay for the games they play. In contrast, only 76 percent of downloaders are willing to pay for news apps.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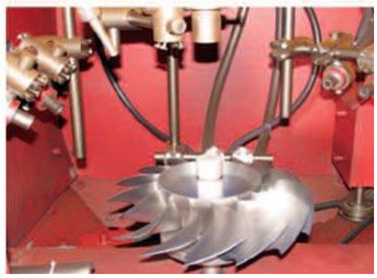

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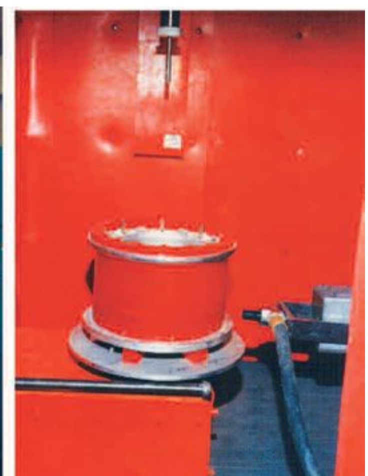

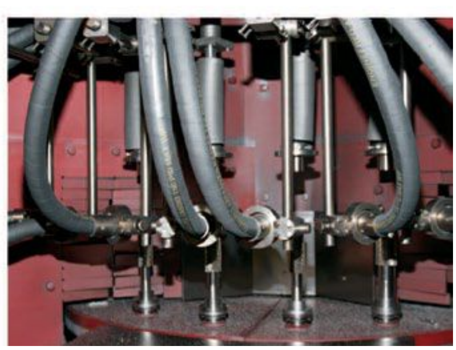

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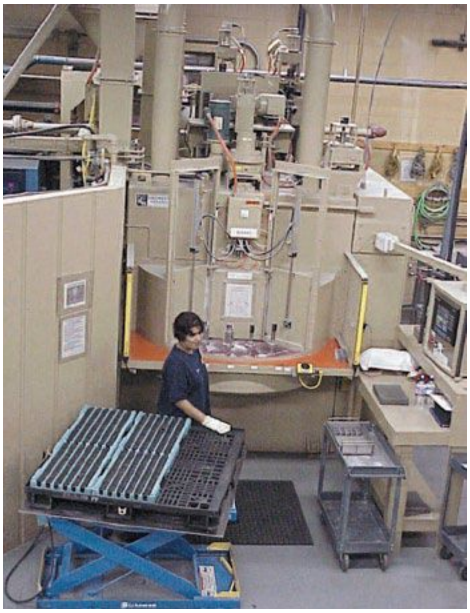

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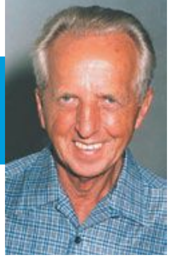


ACADEMIC STUDY

Prof. Dr. David Kirk | Coventry University, U.K.

COMPONENT SHAPE CHANGES CAUSED BY SHOT PEENING

INTRODUCTION

Shot peening is a cold-working process that has the potential to effect useful shape changes. Every cold-working process injects a residual stress system on shaping a metallic component. As a consequence the shape change has two contributions – a plastic contribution and an elastic contribution. This is different from hot-working processes where residual stresses are eliminated by self-annealing so that there is only a plastic contribution. The elastic shape change contribution due to cold-working is a consequence of the residual stress system that is imposed on the component.

Fig.1 illustrates the two contributions that would be involved in any cold-working process that converted a flat strip into a curved strip. The plastic contribution, **hp**, adds to the elastic (residual stress) contribution, **he**, to generate the total deflection, **h**. Hence, **hp** + **he** = **h**.

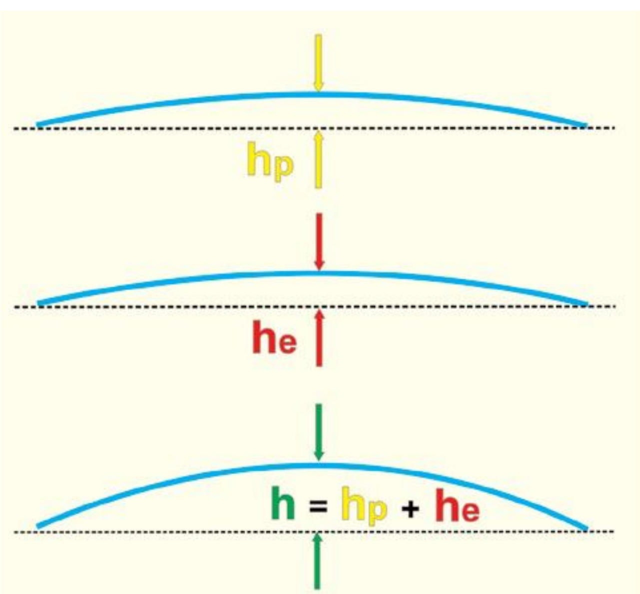


*Fig.1. Addition of plastic and elastic contributions, **hp** and **he**, to bending of strip.*

The elastic contribution is not permanent because it can be eliminated, almost, by stress-relieving treatments. A familiar example is that of peened Almen strips, which reduce their deflections when stress-relieved, leaving only the plastic contribution.

Analysis of shape changes induced by peening is complicated as it involves simultaneous use of both plasticity and elasticity theories. A simplified approach is used in this article by invoking the two theories separately.

Component shape changes are always a consequence of shot peening. These changes may be desirable, undesirable or so small that they can be ignored. Desirable shape changes can be generalized as either "peen-forming" or "distortion rectification" whereas undesirable shape changes can be generalized as "distortion".

The component shape change most familiar to shot peeners is that of an Almen strip. One major face of the strip is peened, which changes its shape from a flat (almost) rectangular shape to a doubly-curved shape. This is a desirable shape change since the induced deviation from flatness, arc height, is a required parameter. The shape change is well-known to have the form of two curves at right angles to one another. Plasticity theory predicts this shape change. Elasticity theory involving bending of beams gives useful predictions of the magnitudes of induced bending. This treats the shape changes as if they were caused by an 'Equivalent Bending Moment'. In effect:

Shot peening induces bending that is the same as would result from applying an external bending moment. This external bending moment is therefore <u>equivalent</u> to the bending moment induced by peening.

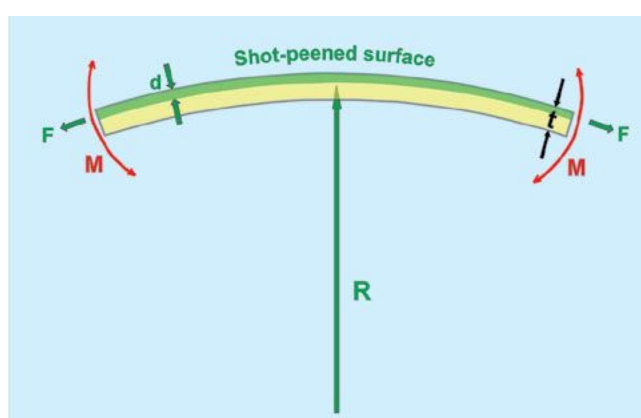


Fig.2. Shot peening shape change parameters.

Fig. 2 illustrates the essential peening parameters that are involved in shape changes. The example shown is that of a peened Almen strip where **d** is the depth of plastic deformation, **t** is the strip thickness, **F** is the bending force generated by the peening, and **M** is the 'equivalent bending moment' that causes the strip to become curved to a radius, **R**. The greater the bending the smaller is the radius of bending.

Curvature is the reciprocal of the radius of bending. Hence curvature increases with the amount of bending because the radius is decreasing. Equation (1) is the fundamental relationship that tells us how bending is induced by the application of a bending moment.

$$\mathbf{R = E.I/M} \qquad (1)$$

where **E** is the elastic modulus and **I** is the rigidity factor for the component (properly called the "second moment of area").

This article aims to show how the fundamental equation (1) can be used to estimate the shape changes that can be induced by shot peening of components. It does not aim to be either detailed or comprehensive but merely to serve as an introduction to the subject for non-specialists.

INDUCED EQUIVALENT BENDING MOMENTS AND RIGIDITY FACTORS

A qualitative feel for bending moments and rigidity factors can be obtained by trying to bend a measuring ruler. Gripped at its ends the ruler is easy to bend – in its 'thin' direction. Gripped with both thumbs touching in the middle of the ruler and it is very difficult to bend. Turn the ruler through 90˚ and it is very difficult to bend (in its now 'thick' direction) even when gripped at its ends. These simple tests illustrate that (a) bending moment is force times distance and (b) that thickness has a much greater effect on rigidity than has width. The rigidity factor, **I**, for a rectangular section is given by equation (2):

$$\mathbf{I = w.t^3/12} \qquad (2)$$

where **w** is width and **t** is thickness.

Shot peening induces a bending moment that is resisted by the rigidity of the component.

SHAPE CHANGE OF ALMEN STRIPS CAUSED BY PEENING

Origin of shape change

The plastic deformation stress requirements for ordinary peening have been described in a previous article (TSP Spring 2006). Fig.3 shows the state of stressing for a very tiny unit cube of material being impacted by a shot particle. The particle imposes a compressive principal stress, -s, in the z-direction and outward material flow is resisted by two identical principal stresses, -r, acting in the x- and y-directions. The Tresca

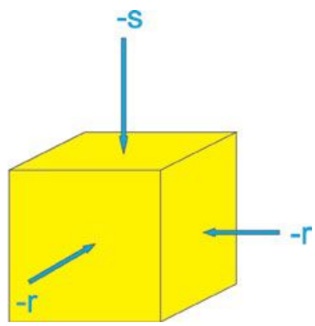


Fig.3. Principal stresses acting on a unit cube of material during shot particle impact.

yield criterion states that yielding will occur if the difference between the largest and smallest principal stresses equals the tensile yield strength, Y. Applying this criterion shows that yielding is equally likely in both x- and y-directions, when Y = -r - (-s) or:

$$\mathbf{Y = s - r} \qquad (3)$$

-r is the largest principal stress because it is less negative than is –s (being a smaller 'bank overdraft' by analogy). The fact that plastic flow is equally-likely in both x- and y-directions means that duplex curvature of an Almen strip must occur.

Magnitude of Shape Change

The shape change of peened Almen strips is usually quantified by the measured 'arc height'. This deflection of Almen strips is the shape change most familiar to shot peeners. Almen strips have a rectangular section of width, w, equaling 19mm but having approximate thicknesses, t, of 0.8, 1.3 and 2.4mm for N, A and C strips respectively. These values readily give us rigidity factors when fed into equation (2). The calculated rigidity factors together with an assumed elastic modulus of 210GPa can then be fed into equation (1). That gives us the relationship between any given radius of bending and the required equivalent bending moment. Radius of bending, however, is not deflection. The next step, therefore, is to convert deflection (arc height) into radius of bending.

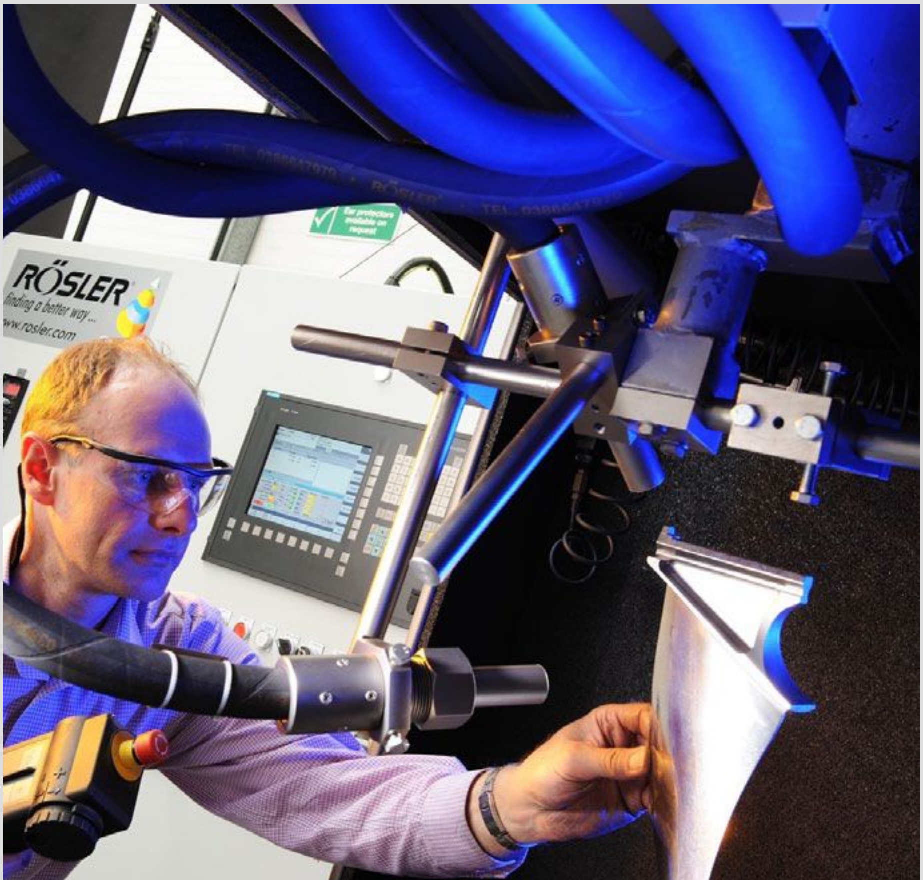
Assuming that the radius of bending is constant along a simply-loaded strip we have the relationship given as equation (4):

$$\mathbf{h = l^2/8R} \qquad (4)$$

where **h** is arc height, **l** is length of Almen strip (76mm) and **R** is the radius of bending.

A complication is that the arc height, h, for Almen strips is made up from longitudinal and transverse contributions, h1 and h2 respectively, see fig.4.

Since the length of an Almen strip is precisely four times its width, equation (4) predicts that h1 should be sixteen times h2.



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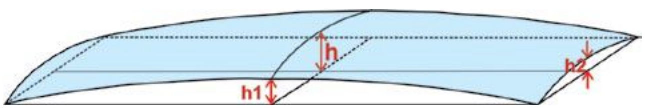


Fig.4. Doubly-curved peen formed Almen strip.

This is an important relationship, as actual measurements will indicate any anisotropy of induced curvature. If the induced curvature is isotropic (same in all directions) then:

$$\mathbf{h1 = l^2/7{\cdot}53R} \qquad (5)$$

Actual measurements by the author indicate that induced curvature of standard-peened Almen strips is substantially anisotropic (h1 being normally only ten times h2). Two explanations are (1) the steel itself is anisotropic and (2) that the standard test involves pre-straining of the Almen strip while it is still held in place by the four screws/bolts.

Required Bending Moments for Almen Strips

Equations (1), (2) and (4) can be combined as rows on an Excel spreadsheet to allow easy estimation of any one unknown factor. Assume, for example, that the one unknown factor is the equivalent bending moment, **M**, induced by peening an Almen strip (**h**, **w**, **t** and **E** being known). An appropriate Excel spreadsheet is shown as Table 1. The arc height of 0·5mm was chosen because it is close to the maximum peening intensity that would normally be applied to components.

Table 1 Bending moments required to give specified arc heights to Almen strips.

Strip Type	E = GPa	w - mm	t - mm	l - mm	h - mm	M - N mm
N	210	19	0.8	76	0•5	119
A	210	19	1.3	76	0•5	506
C	210	19	2.4	76	0•5	3183

It follows that:

Almen arc height is a direct measure of the induced equivalent bending moment.

Re-arranging equations (1), (2) and (4) gives that:

$$\mathbf{M = 2{*}E{*}w{*}t^3.h/(3{*}l^2)} \qquad (6)$$

Equation (6) is a simple linear equation between **M** and **h** and is plotted in fig.5 for the three standard Almen strip thicknesses.

Origin of Bending Moments

Bending moments are the result of force acting through a distance. It is well-known that peening induces a compressive stress and plastic stretching in the deformed surface layer.

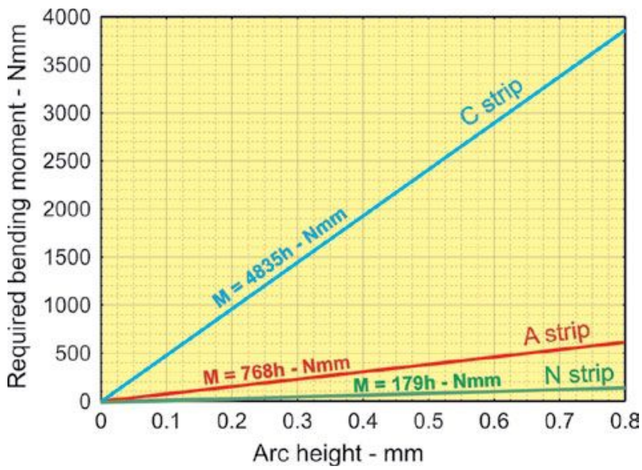


Fig.5. Bending moments required to induce deflections in Almen strips.

The resulting force is equivalent to an average stress, σ, in the peen-deformed surface layer multiplied by the cross-sectional area of the deformed layer. The distance is that from the force to the so-called "neutral axis" of the strip. These requirements are illustrated in the example shown in fig.6.

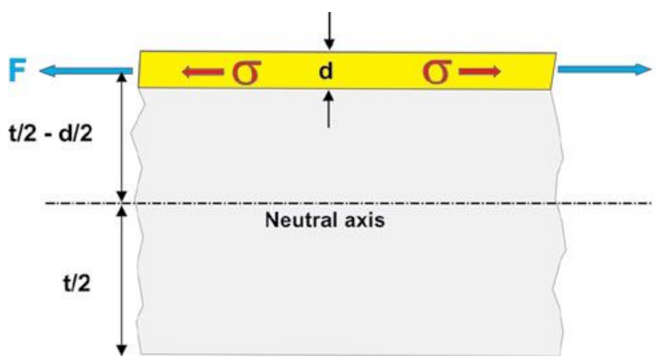


Fig.6. Example of bending moment origin in an Almen N strip.

Take as an example t = 0·80mm, d = 0·05mm σ = 300Nmm^{-2}. The force, F, is then given by F = 300Nmm^{-2} x 0·05mm x 19mm (width of strip) so that F = 285N. This generates a bending moment given by M = 285N x 0·375mm, so that M = 107Nmm.

Uniformity of Bending Moment acting on peened Almen strips

It has been assumed so far that the bending moment generated by peening is uniform, i.e., does not vary either along or across the strip. If that is correct, beam bending theory predicts that a peened strip should take on a parabolic shape rather than a circular one. Actual measurements show that this is indeed the case. One example is shown as fig.7 for which measurements were made along the major axis of a heavily-peened Almen N strip. Data points obtained using a

computer-controlled X-Y-Z coordinate measuring system are shown together with a fitted parabola. The observed uniformity of bending moment is the same as that for the classic example of uniform loading described in beam-bending textbooks.

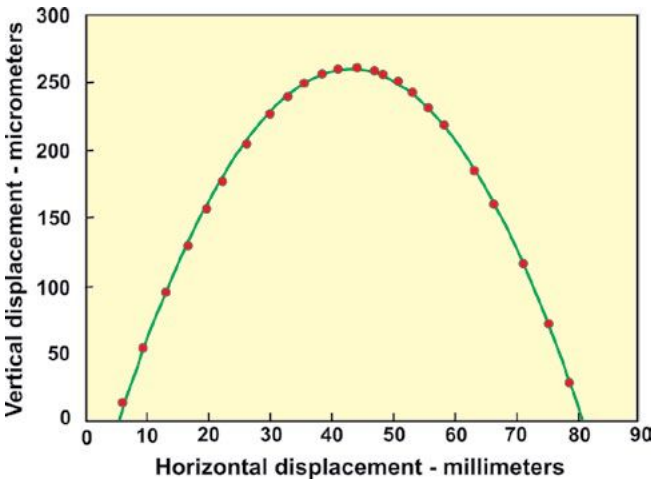


Fig.7. Parabolic shape of a peened Almen N strip.

Variability of Elastic Modulus

The bulk elastic modulus, E, varies with the thermo-mechanical history of the rolled steel strip. Equation (6) when re-arranged shows that an observed arc height, h, is an inverse function of the elastic modulus:

$$h = 3{*}l^{2}{*}M/(2{*}E{*}w{*}t^{3}) \quad (7)$$

This effect is illustrated by fig.8 which shows how measured arc heights vary with elastic modulus. It follows that strip manufacturers must be careful to ensure that the elastic modulus is maintained within fairly narrow limits.

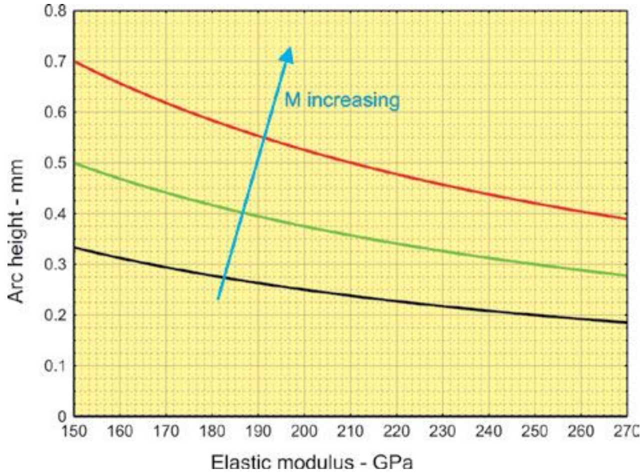


Fig.8. Variability of measured arc height with elastic modulus of Almen strip.

PEEN FORMING OF SHEET METALS

Peen forming of sheet metals is well-established as a metal-working procedure. The curvature that can be induced depends primarily on the thickness and elastic modulus of the metal together with the magnitude of the induced equivalent bending moment. Most peen forming operations are carried out using 'shot' but a few are carried out using 'balls'. A rough distinction is that 'shot' diameters are an order of magnitude less than the sheet thickness whereas 'ball' diameters are of the same order of magnitude.

During peen forming plastic deformation must, of necessity, take place.

Relationship between thickness, elastic modulus and induced equivalent bending moment

Equation (1) can be re-written as:

$$1/R = M/E.I \quad (8)$$

The bending moment, **M**, in the numerator is approximately proportional to the sheet's thickness, **t**, whereas the rigidity factor, **I**, in the denominator is proportional to $\mathbf{t}^3$. Hence the curvature that can be produced is inversely proportional to the square of the sheet's thickness (one power of **t** cancelling). For example, the curvature that can be produced in 10mm thick sheet is only about one-hundredth of that which can be produced in 1mm thick sheet of the same material on applying the same bending moment. Equation (8) shows that the curvature increases linearly with increase of applied bending moment and decrease of elastic modulus.

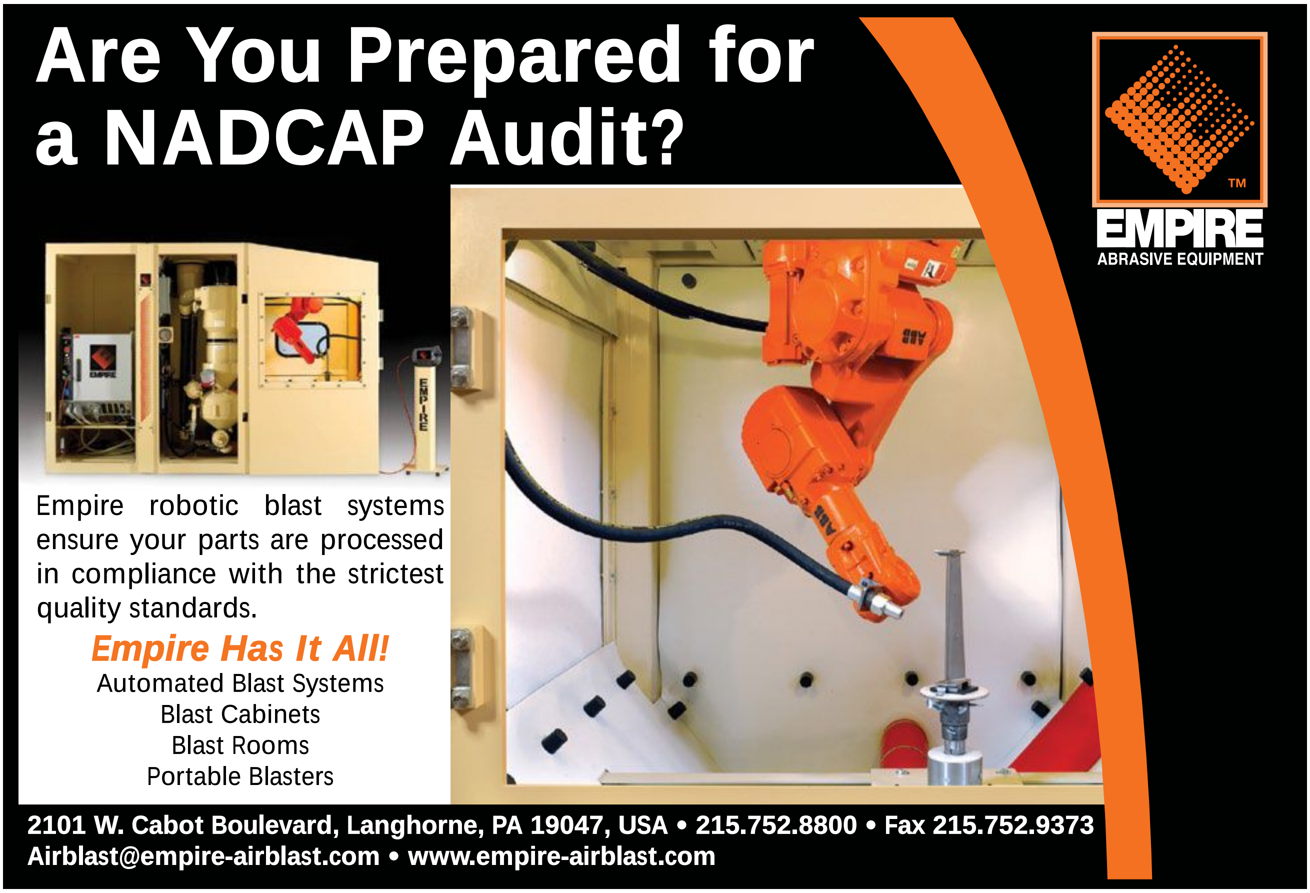
Magnitude of induced equivalent bending moment

A required curvature can only be achieved by the application of the corresponding bending moment, as predicted by equation (8). Values of M for Almen strip steel are readily available. For other materials possible curvatures have to be determined experimentally. A convenient technique is to use samples cut to the 19mm by 76mm Almen strip dimensions. These can then be peened using peening intensity fixtures.

Effect of pre-stressing

In the absence of pre-stressing peen formed sheet will deform equally in two directions. This is not usually desirable. Unidirectional pre-stressing, however, has a profound effect on the principal stress system that is causing plastic deformation during impact of shot particles. This pre-stressing, which can be either tensile or compressive, adds an extra component to the state of stress.

Fig.9 corresponds to where a surface tensile pre-stress, +p, has been applied due to an external bending effect. The largest principal stress is now (+ p – r) and the smallest is still – s. Applying the Tresca yield criterion gives that Y = (+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p - r) – (-s) so that yielding in the x-direction is given by:

$$\mathbf{Y = s + p - r} \tag{9}$$

Comparing equations (3) and (9) shows that the absolute magnitude of the required compressive stress, s, has been reduced by p. For example, a pre-stress of 200MPa would reduce the required value of s by 200MPa (assuming that r remains constant). Reducing the level of stress that must be imparted by the shot particle means that deformation will extend deeper below the component's surface. Pre-stressing therefore strongly encourages yielding in the x- and z-directions and also promotes a greater bending moment. Yielding in the y-direction, on the other hand, is discouraged. That is helped by 'Poisson contraction'.

Fig.10 corresponds to where a compressive pre-stress of magnitude -p has been applied as an external effect. The largest principal stress is now – r and the smallest is still – s. Applying the Tresca yield criterion gives that Y = - r – (-s) so

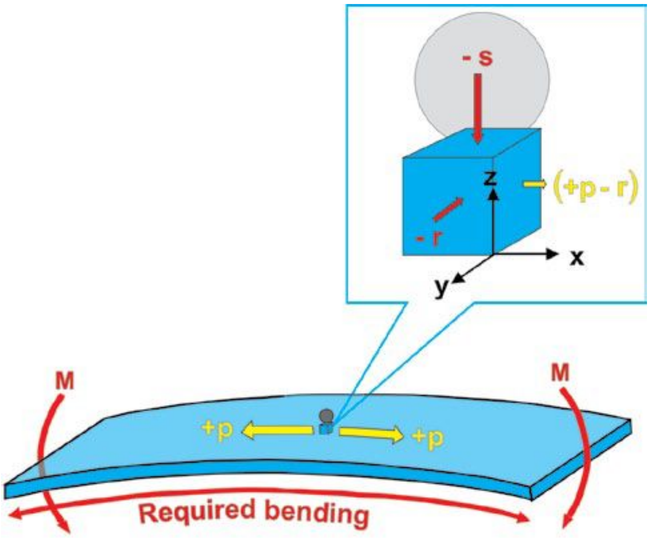


Fig.9. Principal stresses during tensile peen forming.

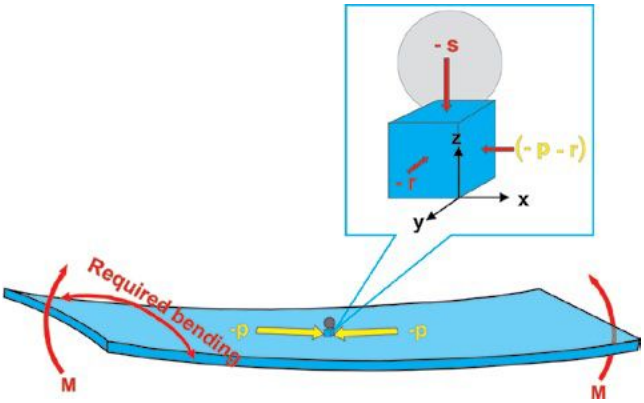


Fig.10. Principal stresses during compressive peen forming.

that yielding in the y-direction is now given by:

$$\mathbf{Y = s - r} \tag{10}$$

Equation (10) is identical to equation (3). This then predicts that compressive pre-stressing will not reduce the impact stress required to cause yielding and therefore deeper deformation will not occur. The resistance to flow in the long direction has, however, been greatly increased - by **p**. Conversely, flow in the cross direction will be encouraged – by the Poisson effect. Note that the bending in the x-direction will be removed when the external applied bending moment, M, is removed.

Distortion Rectification

Distortion rectification is a specialized technique that is generally carried out on an empirical basis. Some distorted components can have the distortion rectified to a degree that may only require minor machine finishing. This is achieved by peening appropriate areas of the component with sufficient intensity. Basic considerations are the bending moment that is imparted, the rectification needed and the rigidity of the component.

The following is a simple example which illustrates some of the basic considerations. A 1m long plate is found to be distorted as shown in fig.11. It is known that peening a 10cm section, AB, would induce a bending of that section to a radius, R, equal to 1m. If we equally peen the underside of the plate between C and D then the plate will bend upwards by the same amount. Estimation of the straightening that would be achieved involves some geometry. The angle COD is given by CD/R or 10cm/100cm so that COD = 0·1 radians. Multiplying radians by 180/À converts them to degrees. Hence the angle COD = 6˚. The angle BEF also happens to be 6˚ (for this example), so that the required rectification would be achieved.

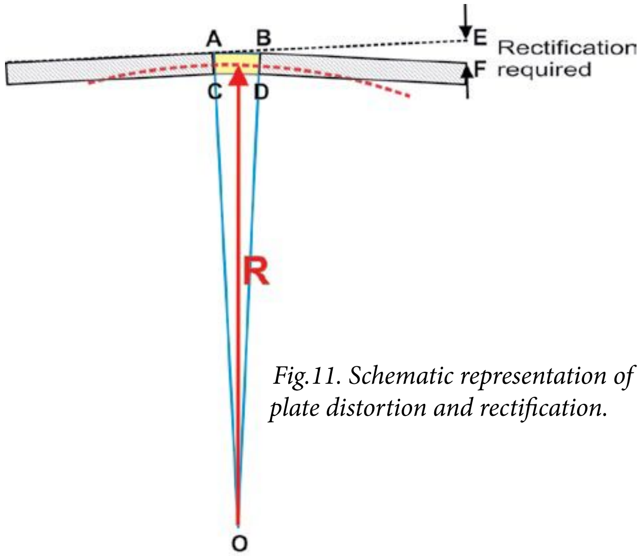


Fig.11. Schematic representation of plate distortion and rectification.

DISCUSSION

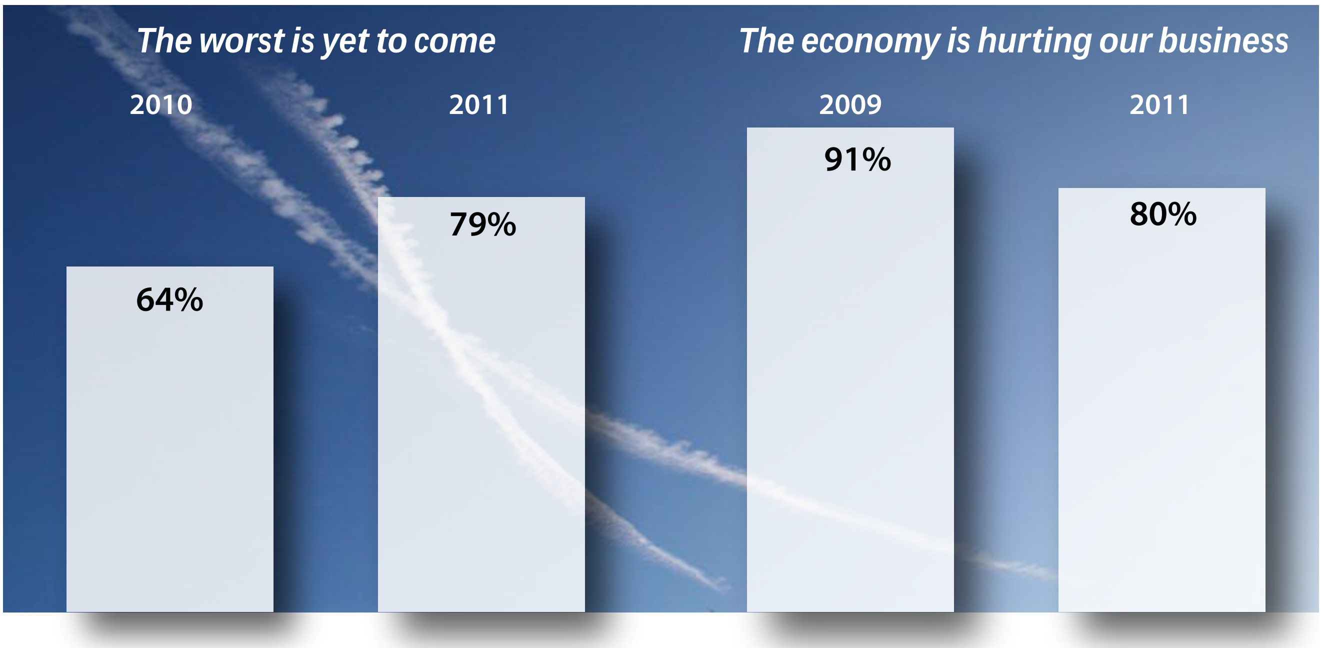
Shape changes are an inevitable consequence of shot peening. The magnitude of these changes can be estimated from knowledge of the imposed bending moment. Analysis of shape change should, however, involve plasticity principles as well as elasticity principles. This was recognized as early as 1865 when Tresca introduced his yield criterion. A deliberately simplified application of plasticity and elasticity principles has been used in this article – in order to reach a larger proportion of shotpeeners.

Almen strips are held down only along their longer edges. As peening progresses a transverse tensile pre-stressing is therefore generated. This transverse tensile pre-stressing will encourage transverse plastic flow. That is a reasonable explanation of the fact that the transverse contribution to arc height is observed to be greater than would be expected from isotropic flow.

Shape changes induced by shot peening can be partially recovered by stress-relieving. If this is undesirable then one solution is to induce excessive shape change and then temper it back to the required shape change.

PRI INDUSTRY POLL

The Impact of the Economic Crisis on the Aerospace Industry



IN OCTOBER 2011, a PRI web poll asked "Do you think the worst of the economic crisis is over?" Of the 348 respondents, 79% feel that the worst is not over. This is up from 2010 where 64% thought they had not seen an end to the decline. However, even though survey participants are expecting the crisis to worsen, another PRI poll indicated that business is being affected less by the economic problems than before.

In July 2011, PRI asked "Is the economy affecting your business?" Eighty percent of the 121 respondents confirmed that it was affecting their business. This number is down from two years prior where, in July 2009, 91% of the 238 respondents felt that their business was being affected by the economy. This suggests that while people do not believe the worst is over, there is less concern about the impact of the economic crisis on the aerospace industry.

About PRI

PRI is a not-for-profit organization created in 1990 by SAE Inc. It exists to advance the interests of the mobility and related industries through development of performance standards and administration of quality assurance, accreditation, and certification programs as well as related activities for the benefit of industry, government, and the general public. Learn more at www.pri-network.org.

THE 9TH INTERNATIONAL CONFERENCE ON RESIDUAL STRESS

October 7-9, 2012

Congress-Centre, Garmisch-Partenkirchen, Germany

THE 9TH INTERNATIONAL CONFERENCE on Residual Stresses is intended as a continuation of the successful series initiated in Garmisch-Partenkirchen (Germany, 1986) and continued in Nancy (France, 1988), Tokushima (Japan, 1991), Baltimore (USA, 1994), Linkoping (Sweden, 1997), Oxford (UK, 2000), Xi'an (China, 2004) and Denver (USA, 2008).

The conference provides a forum for scientists, students, and engineers interested in the prediction, evaluation, control, and application of residual stresses. The aim of this conference is to give equal emphasis to the measurement, modelling, and utilization of residual stress/strain data. Both the scientific and engineering aspects of these topics, such as the influence of residual stress fields on distortion, damage initiation, propagation, component lifetimes, and failure, will be addressed. Emphasis will be laid on method development and current hot topics of great interest, as, for example, stresses in nanosized systems, stress analysis using synchrotron radiation, etc.

CONFERENCE LOCATION

The conference will be held October 7-9 2012 in the Congress Centre in Garmisch-Partenkirchen (Germany). Garmisch-Partenkirchen is located in the Bavarian Alps at the foot of the mountain 'Zugspitze', the highest mountain in Germany (2,962 m/9,724 ft).

Garmisch-Partenkirchen can be reached by car or by train. From Munich Hauptbahnhof, the train ride takes about 1½ hours. Munich International Airport provides connections to many destinations in Europe and abroad.

Accommodation in Garmisch-Partenkirchen can be booked in many different guest houses and hotels. A wide range of accommodation standards and prices, ranging from bed & breakfast-type accommodation to five-star hotels is available. Further information can be found soon on the web pages (keep an eye on www.mf.mpg.de/icrs9).

CALL FOR CONTRIBUTIONS

Participants are invited to submit an abstract of their contribution using the format described in the Instruction for Authors section of the website. The abstracts will be collected in a booklet available at the conference. Contributions can be presented as posters or oral communications, on the basis of author's request and evaluation by the scientific committee. It is planned to publish papers of all accepted contributions in the form of Conference Proceedings. Manuscripts should be submitted at the Conference.

SUPPORT

A number of grants for colleagues from less-favoured countries will be made available. To be eligible, candidates should provide a brief curriculum vitae and the abstract of their intended contribution. Support can be partial or total, depending on fund availability.

DEADLINES AND IMPORTANT DATES

Abstract submission: 29th February 2012
Acceptance notification: 31st March 2012
Registration deadline (*early registration fee*): 15th April 2012
Registration deadline (*full fee*): 1st July 2012

FEES

The conference fee including lunches and dinners as given in the schedule below as well as coffee breaks, abstract booklet and conference proceedings will be in the order of 550 € (early registration) for regular participants and about 300 € (early registration) for students. After the deadline for early registration, the fees will increase by about 100 € with respect to

The Congress Centre in Garmisch-Partenkirchen, Germany
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the early registration fee. The exact fees depend upon sponsoring and fund availability and will be announced on the web pages as soon as possible (keep an eye on www.mf.mpg.de/icrs9). Please note that all conference fees do not include 7% VAT. The ICRS9 Conference is sponsored by the Max Planck Institute for Metals Research.

PRELIMINARY REGISTRATION

Prospective participants are requested to express their interest in participation by sending an email to icrs9@mf.mpg.de containing the following in-formation: Name, affiliation and field of interest (e.g. residual stresses in coatings, diffraction measurement of stresses etc) at any time. You will then be added to a mailing list and receive further circulars and updates by email.

CONTACT AND FURTHER INFORMATION

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RÖSLER EXPANDS FACILITIES IN U.S. AND GERMANY

RÖSLER METAL FINISHING USA has opened a 300,000 sq. ft. campus in Battle Creek, Michigan. The new facility includes Rösler's 15,000 sq. ft. process and test lab, production facilities for both ceramic and plastic media, state-of-the-art finishing equipment, assembly and administrative offices. Remarking on the expansion, Harold Wagenknecht, President of Rösler Metal Finishing USA, LLC, said, "The advantages of a centralized facility with streamlined functions in production, sales, inside sales, marketing and purchasing, as well as our aggressive commitment to our customers, propelled our decision to invest and expand at this critical time."

The family-owned company with 1300 employees worldwide opened their U.S. headquarters in 1999 and has continued to expand, serving customers in virtually every industry, including automotive, aerospace, medical, machining, steel fabrication and green energy.

Expansion in Germany

Two building extensions and additional parking space for 240 cars are underway in Untermerzbach, Rösler's company headquarters in Germany. This latest expansion project represents an additional investment of 3 million euros into this manufacturing location. In the past four years, the company completed four building additions for the integration of the in-house steel fabrication operation, expansion of the overall production volume and warehouse space, and additional floors to the administrative building.

The most recent investment became necessary to overcome capacity bottlenecks due to increased market demand for the company's products and to further expand the in-house manufacturing depth. When the new 3,500 m^2 facility is completed in summer 2012, it will house the complete laser cutting operation. In 2011, Rösler added 60 new employees to its existing staff to assist with the increasing sales volume.

Backed by a global network of locations providing worldwide support and over 60 years of experience, Rösler is the only finishing company offering both mass finishing and shot blasting equipment, as well as the consumables and media for the total process solutions from a single supplier. Dedicated to "finding a better way," Rösler's highly trained employees first evaluate what the end result should be and choose from the most extensive product range in the industry to select the right process for each customer's specific needs.

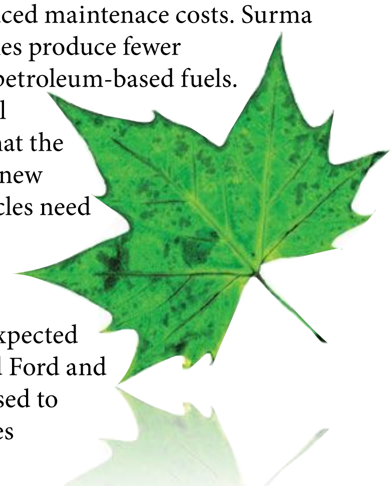
U.S. STEEL CONVERTING VEHICLES TO RUN ON NATURAL GAS

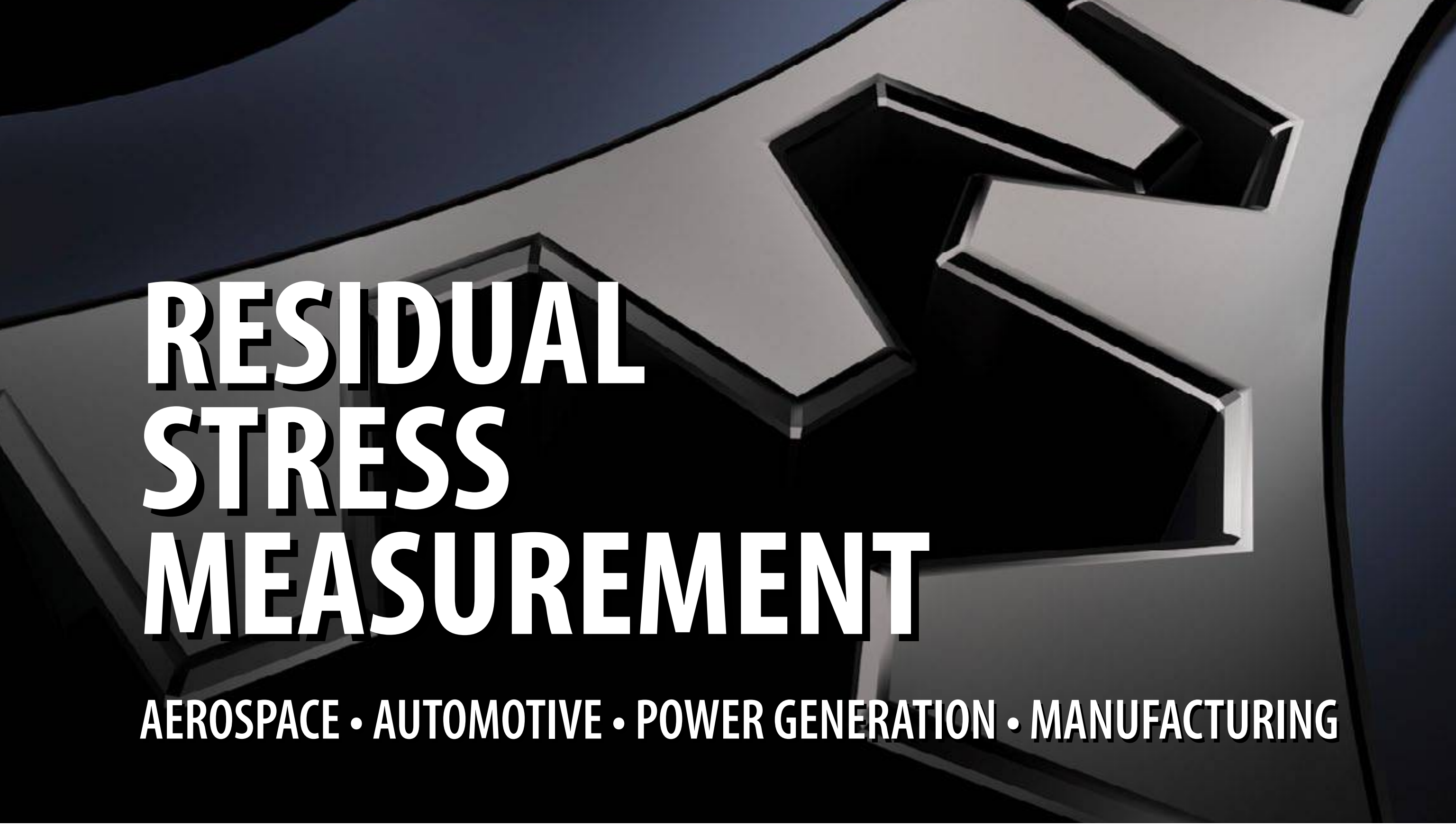
The U.S. Steel Co. is converting its vehicles to run on natural gas, according to a recent article by the Associated Press.

U.S. Steel has installed a natural gas filling station and converted five vehicles at its Mon Valley Works in Irvin, Pennsylvania, including a pick-up truck, a SUV, minivans and a piece of heavy equipment used for moving coiled steel. U.S. Steel is also using six natural gas vehicles and a filling station at its facility in Gary, Indiana.

The steel maker saves 61 cents for every mile driven using natural gas instead of gasoline or diesel fuel, according to U.S. Steel CEO John P. Surma. Surma said that the cost savings are realized through lower fuel costs for natural gas (about 75¢ per gallon) and reduced maintenace costs. Surma also said that natural gas vehicles produce fewer pollutants than vehicles using petroleum-based fuels.

Mon Valley Works General Manager, Scott Buckiso, said that the steel maker hopes to add more new natural gas vehicles as old vehicles need to be replaced since the cost of converting a gas engine to natural gas is around $12,000 - $15,000 per vehicle. Dodge is expected to produce a pick-up truck, and Ford and General Motors are also supposed to have production of such vehicles in the pipeline.





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