

WELDING *Journal*

July 2009

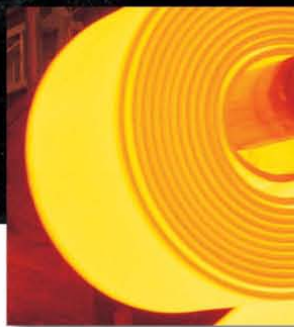


• **Thermal Spray Applications and Technology**

• **Welding Offers Many Career Options**

PUBLISHED BY THE AMERICAN WELDING SOCIETY TO ADVANCE THE SCIENCE, TECHNOLOGY, AND APPLICATION OF WELDING AND ALLIED JOINING AND CUTTING PROCESSES, INCLUDING BRAZING, SOLDERING, AND THERMAL SPRAYING

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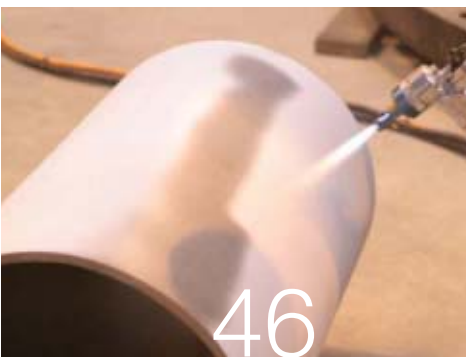
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PRESS TIME

NEWS

Returning Veterans Offered Welder Training by Steamfitters Local 449

Allegheny County Executive Dan Onorato recently announced a \$311,000 grant from the Pennsylvania Department of Labor & Industry to support Steamfitters Local 449's Returning Veterans Welding Program. Eighty veterans will receive 96 hours of beginner welder training during an eight-week period. Basic skills in welding, mathematics, and safety will be provided. The grant will provide \$211,000 for the training and \$100,000 for equipment.

"The Pittsburgh Building Trades believe that those who have protected our country's interests here and abroad should be a priority to receive employment with good wages when they return to civilian life," said Steamfitters Local 449 Business Manager Ken Broadbent.

The Three Rivers Workforce Investment Board (TRWIB) will coordinate the program and serve as fiscal agent for the grant. "As we talk with employers, we understand that welding is a critical skill set that is needed in this region," said TRWIB Chief Executive Officer Ron Painter.

Veterans interested in applying for the training should call Steamfitters Local 449 at (800) 253-6960 or (412) 381-1133. More information is available at www.ua449.com.

AWS Adds to Its Promotional Book Selection

New individual members of the American Welding Society (AWS) now have access to more than 20 promotional books as part of their many member benefits.

Included among these choices are the *Welding Inspection Handbook*, *Arc Welded Projects (Vol. IV)*, and *Total Welding Management* as well as a broadened range of *Welding Handbooks* and the suite of *Recommended Practices* (nine to choose from) and the *Pocket Handbooks* (eight to choose from).

"AWS has expanded the book selection from 5 to about 28 books because we wanted the selection to include a little something for everyone," said Cassie Burrell, AWS deputy executive director. "The books focus on a variety of different welding topics and are a great asset to anyone in the welding industry."

The selections are only for first-time individual members of AWS and all are available for a special one-time price of \$25 for shipping and handling. To become an AWS member and browse the offered publications, visit www.aws.org/membership.

My American Jobs Presents the 'All American Company' Contest

My American Jobs, Inc., Glendale, Ariz., is conducting a contest from its newly completed Web site allowing consumers to select the company they feel best embodies the qualities of U.S. manufacturing. This contest runs until July 31, at which time the top 25 eligible companies entered will move on to the voting stage. In addition, starting August 10 and running until September 4, Internet users can vote for which of the 25 semifinalists is the consumer choice for "All American Company."

The five companies receiving the most votes will win free certification from My American Jobs, Inc., for 2010. Those entrants that were first to select the companies chosen as semifinalists and finalists will receive prizes, too. For complete information, visit www.myamericanjobs.com.

Lockheed Martin to Purchase CTC Facility

Lockheed Martin and Concurrent Technologies Corp. (CTC) have signed a memorandum announcing the plans for Lockheed Martin AeroParts, Inc., to purchase a facility now owned by CTC. The Manufacturing Technology Facility in Johnstown, Pa., is a 197,041-sq-ft facility that contains laboratory and demonstration factory space.

"CTC is helping to create space for 165 new jobs in the region. We will relocate the CTC employees who are currently in the Manufacturing Technology Facility to our Environmental Technology Facility and our Systems Technology Facility, and still have enough room for growth. The transition of CTC equipment and personnel will be phased over the course of the year," said Edward J. Sheehan Jr., president and chief executive officer, CTC.

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EDITORIAL

Do You Have What It Takes to Weld Offshore?

Most welders work in a fabrication shop, plant, or building site. The vast majority of them can drive a car or truck, catch a bus, or even ride a bicycle to their workplace. Work is a short distance from their home. They are able to enjoy all aspects of family life: cheer at their kids' sporting events, attend church, take a hunting or fishing trip, or go to the opera, a movie, or whatever their favorite leisure activity. There's no real restriction on their time other than the eight or more hours worked five, six, or seven days per week.

My career has been witness to a unique challenge not only for the welder but for the employer. At any given time, there are hundreds of construction workers — including lots of welders — working offshore in the Gulf of Mexico. With nearly 4000 structures out there all made of steel, there is a constant need for welders. The welders may drive many miles to reach their dock for mobilization. They then reach their workplace — sometimes more than a hundred miles offshore — by marine vessel or helicopter. They can be working from a pipeline lay or derrick barge, on a platform, a lift boat, or any form of marine construction vessel. Their work assignment can last for a couple of days or a few weeks. They are qualified in any number of welding processes — SMAW, FCAW, and GTAW. The materials range from carbon steel, aluminum, and Inconel™ to stainless steel. The welds are commonly subjected to ultrasonic, magnetic particle, or radiographic testing.

The welders work long hours in weather and surroundings that can be very harsh and miserable. Imagine welding on a process flow line while hanging beneath a deck during winter, suspended in a "Spider" 45 feet above the water with little to break the wind to protect your weld except for your body. Your movements are restricted by the fall protection and floatation devices you must wear. Any movement on your part makes the "Spider" move like a pendulum. Of course, the weld when completed will be subjected to radiography. This is not your common set of parameters for successful welding, and this is not your common workplace. These guys and gals are "real" welders.

On the employer side, you need skillful employees who must pass a drug test in addition to their welding tests. Your employee must be willing to work and live away from home and family in strange surroundings for extended periods of time at which the food can be real good or real bad. The employee has to pass a physical and other tests to see if they can physically do the work. The ability to climb, lift, swing from a rope, and crawl is required to work offshore. Safety is of the utmost importance to any contractor or oil and gas operator working in the Gulf of Mexico. This industry is constantly graded and scrutinized with regard to safety. The employer has to constantly monitor the wage market. Let the welder find out that another employer is offering more money and there can be trouble. The welder has to be able to support his or her family with the sometimes inconsistent wages from offshore work.

The offshore welders I've known are among the best welders in the world. They are dedicated, skillful, and produce an extraordinary amount of work. Our industry relies on them day in and day out to keep the platforms running. Their safety culture is second to none and steadily improves. If you have ever wanted to challenge your skills as a welder, come to the Gulf of Mexico. There is always a demand for quality welders, and the employers are top class.



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NEWS OF THE INDUSTRY

Airgas 'Pit Crew' Welders Perform Emergency Wheelchair Repairs at Quad Rugby Tournament



A couple of athletes compete in quad rugby, a game played with a volleyball on a basketball-size court with goal lines marked by cones and a lined-off "key" area. (Photo courtesy of Bob Long Photography.)

Airgas piloted an on-site welding repair shop at a quad rugby tournament earlier this year in Jacksonville, Fla. The game, a mix between wheelchair basketball and demolition derby, is a rough, full-contact sport deserving of its "Murderball" nickname. For many players, however, the toughest part is sitting on the sidelines with their custom rugby wheelchairs too banged-up to be allowed back on the court. Luckily, this did not have to happen at this event.

Kent Carter, area vice president—central, arranged for Airgas South's mobile Arcs-N-Sparks welding machine demo unit to be available as a home base. "All in all, this was a terrifically rewarding experience for Airgas to support these courageous athletes, and we gained tremendous respect for their abilities and competitive drive, as this sport is fascinating to watch and the sportsmanship we witnessed was incredible," said Carter.

A team of Airgas South associates — made up from different branches with Mark Andersen, Scott Carter, Norm Cobb, and Tim Hill from Jacksonville, Fla.; Tom Beda and Rick Chancey of Leesburg, Fla.; Herbie King from Orlando, Fla.; and Carter; plus one customer, Wayne Eckhart of Progress Rail — performed emergency welding repairs for 16 damaged wheelchairs.

The first player rolled in five minutes after the welding team got set up. For the next five hours straight, this "pit crew" welded, cut, shaped, bent, and filled. They even consulted books for working on titanium and aluminum.

Gas tungsten arc welding was primarily used along with gas metal arc welding. The parts welded included frame support joints, front axles, front picker crack repair, and seat support joints. Most of the chairs were manufactured from aluminum tubing, while some were titanium, with wall thicknesses of 0.085 to 0.120 in. The fronts of some chairs also have up to ¼-in. aluminum plate.

One player, Robbie Parks, traveled from North Carolina only to break the back rest on his game chair and the frame on his backup chair during warm-ups. He was back on the court by game

time. "The Airgas crew saved the tournament for Robbie," said Mike Duda, coach of the Carolina Crash quad rugby team. "While they were fixing his chair, they even found and fixed several more potential weak spots and cracks. In total, they fixed cracks and potential safety issues for five of our eight chairs."

The welding team faced its share of challenges, too. No two chairs were the same because each one was designed to meet the individual player's needs. There were several hard-to-reach weld zones that required a couple of people turning and holding the chair in place while the welds were made. Some of the repairs to the front of the defensive chairs required grinding and overlay to bring them into compliance with quad rugby rules and specifications. In addition, the repairs were made outside with a mobile welding trailer, presenting gas flow challenges.

With 30 min between games and coaches eager to get their best players back on the court, there was a rapid-fire, *Indiana*



Welding saved the day for players. Here, Airgas South associate Herbie King uses the gas tungsten arc process while Scott Carter assists by steadying the workpiece.

Jones feel in the repair area, said David Harrigan, vice president of logistics for Airgas. He performed "roadie" work for this pit crew, rolling rugby chairs back and forth between the gym and welding team.

Harrigan's primary role was to get word to the players and coaches about the company's services as well as watch his son, Mike, play in the tournament. In 2006, Mike was involved in a single-vehicle accident that left him paralyzed from the chest down. A former high school football player, Mike took immediately to quad rugby during his rehabilitation. Now his dad is hoping other Airgas associates can find a way to support Mike's new passion and a very special group of wheelchair athletes.

"My vision is to make this happen for quad rugby tournaments around the country," said Harrigan. "We proved we could do it in Jacksonville, and seeing the faces of the players as we fixed their rugby chairs showed that it meant the world to them."

Information courtesy of Airgas, Inc., Radnor, Pa. To learn more about the United States Quad Rugby Association, visit its Web site at www.quadrugby.com.

Ford Team Wins Inventor Award for Energy-Efficient Engine Technology



Ford, along with Flame-Spray Industries, recently won the 2009 National Inventor of the Year Award from the Intellectual Property Owners Education Foundation. As pictured above, a thermal sprayed wear-resistant, low-friction deposit gets applied to a Ford ZETEC 1.4-liter VCT engine. (Photo courtesy of Ford Motor Co.)

The Intellectual Property Owners Education Foundation has presented its 2009 National Inventor of the Year Award to Ford and Flame-Spray Industries for the collaborative development of the spray apparatus for use with Ford's patented production-ready plasma transferred wire arc (PTWA) thermal spray deposit process for aluminum engine blocks.

At an awards ceremony in Washington, D.C., the team of inventors honored included Ford retiree James Baughman and David Cook (a member of the Ford team when the spray device initially was developed), Keith Kowalsky, and Daniel Marantz of supplier Flame-Spray Industries.

This development replaces heavy cast iron liners, which improves an engine's fuel efficiency by reducing engine weight and internal piston friction losses. A low-friction, wear-resistant thermal spray deposit is provided. In addition, Ford has 95 issued and pending patents related to the new PTWA deposit technology and will introduce it on its North American power train lineup within the next year.

Society of Manufacturing Engineers Seeks Award Nominations

The Society of Manufacturing Engineers (SME), Dearborn, Mich., has issued a call for nominations to be submitted for various awards. The deadline for all of these is August 1.

The categories are as follows: Eli Whitney Productivity Award, Joseph A. Siegel Service Award, SME Gold Medal, SME Frederick W. Taylor Research Medal, Donald C. Burnham Manufacturing Management Award, SME Albert M. Sargent Progress Award, SME Education Award, Outstanding Young Manufacturing Engineer Award, and the Award of Merit.

Nomination forms can be downloaded from each individual award's landing page or at sme.org/awards. Nominations must include two letters of recommendation, one of which can be provided by the nominator.

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Lincoln Electric Dedicates New Welding Consumables Facility in India



Lighting the Kuthuvilaku took place as part of Lincoln Electric's ceremony for its new manufacturing plant in Chennai, India. From left are Ganesh Gurushankar, managing director – Lincoln Electric India; Vinod Kapoor, vice president, global operations development; John M. Stropki, chairman, president, and CEO – Lincoln Electric Holdings; Thomas A. Flohn, president – Lincoln Electric Asia Pacific; and Frederick G. Stueber, senior vice president, general counsel, and secretary.

Lincoln Electric Holdings, Inc. recently dedicated a 100,000-sq-ft welding consumables facility in Chennai, India. It will serve

the growing market in that country as well as markets throughout the Asia Pacific region.

"The new Chennai plant represents an important investment for Lincoln in the expanding market for welding products in India. Our plant will serve the growing demand from industry and large infrastructure projects that are fueling India's economic growth," said John M. Stropki, chairman and chief executive officer.

This facility will manufacture solid welding wire used for a variety of welding applications in industry segments such as heavy equipment, metal buildings, pipeline and pipe mills, and power generation. Additionally, the new campus consists of offices for the company's new Indian headquarters, training and welding demonstration facilities, and manufacturing space.

International Thermal Spray Conference and Exposition Is a Success

The International Thermal Spray Conference and Exposition (ITSC 2009), held at the Flamingo Las Vegas Hotel in Nevada from May 4 to 7, attracted 800 attendees and participants from 30 countries. The ASM Thermal Spray Society (TSS), the German Welding Society (DVS), and the International Institute of Welding organized this event.

Its theme, "Expanding Thermal Spray Performance to New Markets and Applications," touched on all aspects of the supply chain. Featured events included the Legends of Thermal Spray session; plenary talks by Tocalo and Messier-Dowty; market-focused talks by representatives from India, Korea, and Nordic Europe; and a dedicated program on reliability and consistency.

Mitch Dorfman with Sulzer Metco (US) Inc., who is also president of the ASM TSS and general co-chair for ITSC 2009,



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Mitch Dorfman (shown behind the lectern) speaks during the International Thermal Spray Conference and Exposition 2009 opening session. He served as general co-chair for this event.

said it was an honor to share the lectern with general co-chair Peter Heinrich, Jens Jerzembach of DVS, and Thom Passek, ASM TSS executive director. He went on to thank Charlie Kay of ASB Industries and event manager Natalie Nemec of ASM International.

Mazak Hosts Ribbon Cutting for Laser Technology Center



Bill Citron, president of Mazak Optonics Corp., cuts a ceremonial ribbon for what the company believes is the world's largest dedicated Laser Technology Center. Located in Elgin, Ill., this new building encompasses 50,000 sq ft. In the back row (from left) are Doug Whitley, president of the Illinois Chamber of Commerce; Ted Niwa, vice president of Mazak Optonics; and Elgin Mayor Ed Shock. Bob St. Aubin, vice president of sales and marketing, helped to host the ceremony. The center represents a total investment of \$25.6 million in the North American fabricating industry. Currently, 13 laser machines are under power with a capacity for up to 18 units.

Industrial Metal Supply Expands Riverside Facility

Industrial Metal Supply Co. (IMS) is reconfiguring its Riverside, Calif., warehouse facility as the company's regional distribution center serving Riverside and Orange counties.

— continued on page 99



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INTERNATIONAL

UPDATE

Disk Lasers Weld Doors and Body Reinforcements of Peugeot 3008



The layout of the disk laser technology that is being used to weld parts for the new Peugeot 3008.

PSA Peugeot Citroën is using three TRUMPF TruDisk 6002 and one TruDisk 4002 lasers to weld the doors and body reinforcements of its new model being launched this summer. The disk lasers, which range in power from 4 to 6 kW, lay a full-length weld joint rather than individual spot welds.

"This enables us to achieve high body stiffness in our new Peugeot 3008," said Jean-Charles Schmitt, product and process laser manager at PSA. In addition, use of the disk laser allowed the company's engineers to develop new design options. "Compared to conventional spot welds, full-length weld seams in car body manufacturing require less sheet folding and thickness due to a specific laser design, and thus saves about 5 kg of weight per vehicle," Schmitt said. The company could also increase the size of the rear-quarter windows, allowing better visibility for the driver and passengers.

The four lasers are located at the assembly plant in Sochaux, France. They supply ten processing stations, which the TRUMPF LaserNetwork in turn supplies with the necessary laser power for welding.

Saskatchewan College Offers Program to Help Welders Become Journeymen

The Swift Current campus of Great Plains College, Saskatchewan, Canada, recently began a Welder Upgrader program for individuals possessing the necessary practical hours (8100 h) needed for welder journeyman certification.

Welding is a noncompulsory trade in the province, which means a person is required to verify 8100 h of welding experience in order to qualify for the program. The Welder Upgrader program includes a practical and a theory component.

"We are delivering this program over the course of four months as opposed to the seven-week format that is being offered elsewhere," stated Karen Richmond, program coordinator. "We chose this delivery method as it causes minimal disruption in the students' jobs because the class is offered Fridays and Saturdays and therefore the student only has to take one day a week off from work. This is also ideal for employers."

The college is applying to the province's Apprenticeship and Trade Commission to be able to offer the program again in the fall. For more information, visit www.greatplainscollege.ca.

Ultrasonic Equipment Delivered to China High-Speed Rail Wheel Manufacturer

GE Sensing & Inspection Technologies, Billerica, Mass., is providing phased array ultrasonic inspection equipment to Taiyuan Heavy Industry Co. (TYHI), a manufacturer of rail wheels, axles, and wheel sets in China. The machines can perform inspection of an entire wheel in one minute.

The turnkey system was specially developed for railway applications. It includes two phased array probes that inspect the wheel from the tread surface to the rim surface. The phased array probes can be easily adjusted for inspection of a variety of wheels, which improves the efficiency of the process and reduces the inspection cost.

Australian Army Purchases Six Additional Virtual Reality Welding Trainers



The Australian Army is adding six SimWelder™ virtual reality welding trainers similar to this one to its training facilities.

The Australian Army is adding six SimWelder™ turnkey virtual reality welding trainers to the one it bought in 2008. The installation will include training capabilities for gas metal arc welding (GMAW) for mild steel butt joints and aluminum T, corner, and butt joints in multiple positions, as well as shielded metal arc welding (SMAW) for mild steel T and butt joints in multiple positions.

Welding is a critical skill for construction, repair, and maintenance — both on and off the battlefield — for most military vehicles and equipment made of

metal. The U.S. Army and Marines have eight SimWelder™ GMAW/SMAW combo bays at Aberdeen Proving Ground in Maryland. The training equipment augments traditional welding training by providing instructors with objective feedback and allowing trainees to do more repetitions without the added costs of materials, consumables, and energy. When using the equipment, students hold a real welding torch and wear a real welding mask while working in an interactive, computer-generated environment.

Rofin Delivers CO₂ Slab Laser Number 5000 to Daimler



Messrs. Beichter, Kerestes, Lorenz, and König from Daimler AG, Dr. von Stamm from Rofin-Sinar Laser GmbH, and Mr. Klotz from Arnold GmbH pose with the DC 050 CO₂ slab laser recently delivered to Daimler in Stuttgart-Hedelfingen, Germany.

Rofin-Sinar Laser GmbH recently delivered a DC 050 to Mercedes-Benz in Stuttgart-Hedelfingen, Germany. The machine the company provided to the automobile manufacturer is the 5000th CO₂ slab laser it has produced.

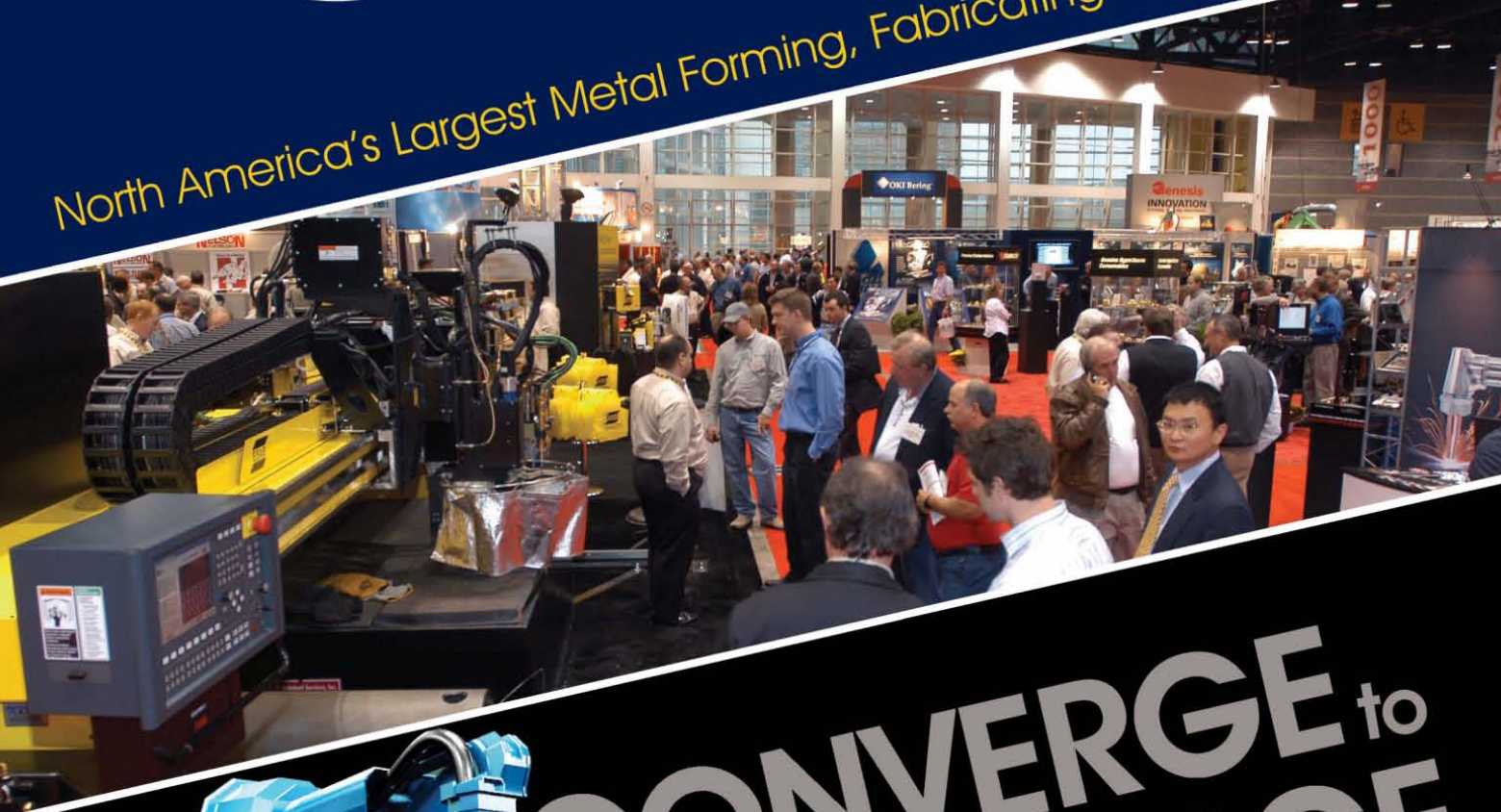
The laser will be used in an existing two-station laser beam welding machine from the German mechanical engineering company Arnold to weld planet carriers. Daim-

ler has been welding the planet carriers since 2002. The laser processes the planet carrier in the all-wheel component of the automatic gearbox 7G-TRONIC. This all-wheel component has helped Daimler increase traction while reducing consumption of fuel from 1 to 0.4 L per 100-km traveled. ♦

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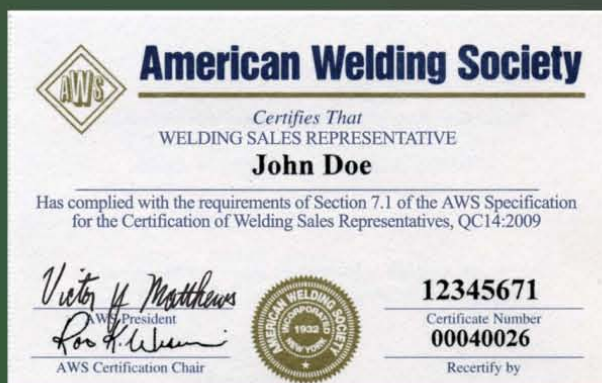
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RWMA

Q&A

Q: I received a flash welding machine from one of our other facilities and have been asked to retool it for a new product we are to release. This is not the same application that the welding machine was welding at the other plant, but it is the same 1020 steel material. How do I know that this welding machine is the right size to do the job? We do some spot welding, and I am familiar with this process.

A: Obviously, if you were welding rod or flat sheet material and the welding machine was tooled for an application similar to yours, you could make some simple setups with the existing tooling and weld some samples. However, as in your case, it is not always that simple. Since I don't know all the particulars of your welding machine and the application, let's begin by discussing some of the basics of flash-butt (upset) welding.

Flash welding is one of the four types of resistance welding along with spot, projection, and seam welding. As such, it shares many characteristics with the other three processes but it does differ in some respects.

The basic flash welding process is broken down into a flashing stage and an upset stage to complete the weld. The flashing generates heat in the ends of the two abutting surfaces. The application is clamped into the tooling with one part on a stationary table and the other on a movable table with sufficient pressure. The two pieces of metal — in your case 1020 steel — are placed adjacent to each other in light contact. With the weld current applied, the heat generated by the intense flashing arc and the combustion of the metal in the arc then reaches the fusion point. At that time, the second portion of the process begins when the speed of the movable table increases forging (upsetting) the two pieces together.

This seems fairly straightforward, so now we look at the parameters required and some general rules of thumb to find out if you have been given the proper welding machine. The applications of flash welding are almost unlimited for ferrous and nonferrous metals and are governed by design. In your case, 1020 steel is a fairly simple material to flash weld.

Upset Force (Forging)

Let's look at how much forging force is required. First, review the material to be welded and determine, based on tensile and yield strengths, the upset force required to forge the 1020 steel. Al-

BY LARRY MOSS

though there are varying factors we will discuss later, for 1020 steel, we will use 10,000 lb of force for every square inch of material at the weld joint. We then calculate the cross section of the application. This will give you the amount of upset force the welding machine will need to supply during the upset stage. In the case of a hydraulic-actuated cylinder, we can calculate the pressure and diameter of the cylinder to see if it meets this requirement. Speed of the upset is also important to minimize oxidation of the high-temperature weld surfaces. The upset distance is also important, and a rule for flat or tube applications is as follows: $\frac{1}{2}$ the material thickness + $\frac{1}{16}$ in. For round or square solid applications, the rule is $\frac{1}{4}$ of the diameter + $\frac{1}{16}$ in.

Clamping Pressure

If a material or application can be backed up on the clamping tooling, it will reduce the amount of clamping pressure needed. If it is not practical as in your case, and the clamps need to do all of the work, then the clamping pressure must be much greater than the upset pressure. Although we use another rule of thumb of a two-to-one ratio of clamping force to upset force, there are several factors to consider such as surface condition of material, electrode and clamp material of the welding machine, and contact area of clamps. In some applications where surface marking is not critical, serrated upper steel clamp dies are used to grip the material. The main objective is not to allow the parts to be welded to slip in the clamps during the flash and upset stage.

Current

Welding currents vary with the type of stage one flashing speed and secondary voltage. One of the differences between flash welding and spot welding is that if you can sacrifice the time of each weld, you can normally weld a larger application or cross section. Although kVA rating is a thermal rating, we use another rule of thumb to approximate welding currents when flashing: When welding round or square solid sections use 50 kVA (AC) for every 1 in.² of mild steel at 8-s flash time. The 8 s being the variable; if you want to weld twice as fast (4 s), you would require 100 kVA and so on. For flat sheets and tubes add about 30% more for the greater exposed surface radiation and the reduction in intensity.

Secondary Voltage

During the flashing stage, the lowest secondary voltage should be used that will permit a smooth even flash. The secondary voltage adjustment on the tap of your transformer adjusted with the speed of the movable table will allow weld consistency to be at its peak. Remember, too, that a proper flash welding machine will have some type of acceleration in the flashing stage to assist in keeping the flash smooth as the material heats up. Higher voltages will expel material that was heated leaving you with a small heat-affected zone and result in insufficient upset.

Flash and Upset Distances

A common question is how much material do I add to my product to allow for flashing (melt-off) and upset distance? We quickly covered the upset distance rule of thumb under upset force and the flashing or melt-off distance rule of thumb for tubing or flat sheets would be nine times the thickness of the material below 0.070 in. thick and six times the thickness above.

Available data is in the *RWMA Handbook* 4th edition, Section 5-1 with flash and upset distance charges including material clamping distances that give excellent starting parameters for a variety of thicknesses. Also, the *AWS Welding Handbook*, 9th edition, Vol. 3, is a very good reference for finding parameter data for flash welding.

Your welding machine should have data tags showing available pressure and transformer secondary voltage ratings. Along with machine operation manuals and the tips included here, you should be well on your way to determining if the welding machine you have is right for your application. ♦

LARRY MOSS is president, Automation International, Inc., Danville, Ill. He is a member of RWMA and was chair of the Welding Handbook Chapter Committee on Flash and Upset Welding. Questions may be sent to Mr. Moss c/o Welding Journal, 550 NW LeJeune Rd., Miami, FL 33126, or via e-mail at lmoss@automation-intl.com.

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STAINLESS

Q&A

Q: I need to make a series of lap fillet welds of mild steel, 1/4 to 1/2 in. thick, on 304L stainless steel sheet and plate that is anywhere from 1/4 to 1/2 in. thick. In every case, the mild steel thickness will be less than or equal to the 304L stainless steel thickness. I am considering making these welds by GTAW without filler metal. Is this an acceptable approach?

A: Note that this is the converse of the question published in my May 2009 column in which 304L stainless steel was the upper piece of the joint. The question was asked for both combinations, but the approach for developing the response is different in the case where mild steel is the upper piece. Figure 1 shows a sketch of the currently proposed situation.

As in the May column, in an autogenous lap fillet weld, the fused metal is likely to consist of between 60 and 90% of the upper piece, in this case the mild steel. The remaining 10 to 40% of the fused metal will come from the 304L. Since the majority of the fused metal is from the mild steel, the discussion of May 2009 concerning solidification mode as primary ferrite or primary austenite is not germane to the current situation. Instead, hardenability, susceptibility to hydrogen-induced cracking (HIC) of the fusion zone, and likely mechanical properties of the fusion zone are the main concerns because the fused metal must have compositions akin to low-alloy-steel weld metal. For 60 to 90% mild steel, balance 304L, Table 1 shows calculated fused metal compositions beginning with typical mild steel and 304L compositions.

Table 1 also includes calculated “carbon equivalent” and “composition parameter” for the fused metal. These indexes are used for estimating hardenability, likelihood of HIC in a mild steel or low-alloy steel HAZ of a given composition, and preheat temperatures appropriate for avoiding HIC. While not originally developed for fused metal, they have applicability to fused metal as well as the HAZ. Annex I of

BY DAMIAN J. KOTECKI

AWS D1.1/D1.1M:2008, *Structural Welding Code — Steel*, indicates that, when the CE exceeds 0.50% and the carbon content exceeds 0.10%, the steel is highly hardenable and very susceptible to HIC. At all dilution levels shown for fused metal in Table 1, the CE exceeds 0.70% and the carbon content is at least 0.10%. At this carbon level, if the fusion zone transforms to 100% martensite, hardness of 35 to 40 Rockwell C would be expected. On the other hand, the CE of the mild steel is much too low for there to be concern about its HAZ, and the HAZ of the 304L is of no concern because it cannot be hardened by a thermal cycle. So, only the fusion zone is of concern with regard to hardenability, HIC, and mechanical properties.

Autogenous GTAW produces very little diffusible hydrogen—less than 1 ppm would normally be expected. This is considerably below the lowest hydrogen level envisioned in Annex I of AWS D1.1/D1.1M. So the guidance given there should be quite conservative for the present situation. Applying the guidance of this Annex for the case of 90% mild steel in the fusion zone and less than 1/4 in. thickness, the P_{cm} approach would call for less than 65°F (18°C) preheat to avoid HIC. For 80% mild steel in the fusion zone, the needed preheat would likely be 140°F (60°C). The cases of 70% mild steel and 60% mild steel in the fusion zone go beyond any level of P_{cm} considered by the D1.1 Code. Preheat above 300°F (150°C) may be needed to avoid cracking for these latter two conditions, but you should be able to make the joint without HIC with appropriate preheat. If you choose to go ahead, I suggest you study Annex I of the D1.1 Code and use it to guide you in preheat selection.

If HIC can be avoided, the next concern is the needed mechanical properties of the weld. Even with preheat of 300°F or more, a weld fusion zone corresponding to any of those shown in Table 1 is likely to exhibit very high strength, but very low ductility and toughness. I would expect tensile strength between 120 and 170 ksi



Fig. 1 — Sketch of autogenous GTAW lap joint of mild steel on 304L.

(830 and 1200 MPa), tensile elongation of less than 10%, and toughness on the order of 10 ft-lbf (14 J) at room temperature from such a fusion zone as any of those shown in Table 1. The root of the joint is a built-in notch, and the fillet size from autogenous GTAW is likely to be considerably smaller than would normally be used with filler metal unless your welding conditions produce higher dilution of the 304L into the fusion zone. I think it would take very little mechanical strain to fracture the weld. You have to decide if that is adequate for your application in view of the possible consequences of a failure.

I don't think it is possible to consistently produce an autogenous GTAW lap fillet joint of 90% mild steel in the situation proposed. Lesser amounts of mild steel (greater than 10% 304L) in the fusion zone are likely to have worse toughness and ductility. You have to decide if this is acceptable for your application. My suggestion would be to avoid this by using 309L filler metal with GMA or SMA for the fillet welds. ♦

DAMIAN J. KOTECKI is president, Damian Kotecki Welding Consultants, Inc. He is a past president of the American Welding Society, currently treasurer and a past vice president of the International Institute of Welding, and a member of the AWS A5D Subcommittee on Stainless Steel Filler Metals, and the AWS D1K Subcommittee on Stainless Steel Structural Welding. He is a member and past chair of the Welding Research Council Subcommittee on Welding Stainless Steels and Nickel-Base Alloys. E-mail your questions to Dr. Kotecki at damian@damiankotecki.com, or mail to Damian Kotecki, c/o Welding Journal, 550 NW LeJeune Rd., Miami, FL 33126.

Table 1 — Typical Base Metal and Calculated Fused Metal Compositions

Composition	Alloy		Calculated Fused Metal Compositions			
	304L	Mild Steel	90% Mild Steel	80% Mild Steel	70% Mild Steel	60% Mild Steel
C, %	0.02	0.15	0.14	0.12	0.11	0.10
Mn, %	1.20	0.70	0.75	0.80	0.85	0.90
Si, %	0.40	0.20	0.22	0.24	0.26	0.28
Cr, %	18.50	0.00	1.85	3.70	5.55	7.40
Ni, %	10.50	0.00	1.05	2.10	3.15	4.20
CE, %	n.a.	0.30	0.74	1.18	1.62	2.05
P_{cm}	n.a.	0.19	0.29	0.39	0.49	0.59

Notes: CE is the “carbon equivalent” ($CE = C + Mn/6 + Si/6 + Cr/5 + Mo/5 + V/5 + Ni/15 + Cu/15$) according to Annex I of AWS D1.1/D1.1M: 2008). P_{cm} is the “composition parameter” ($P_{cm} = C + Si/30 + Mn/20 + Cu/20 + Ni/60 + Cr/20 + Mo/15 + V/10 + 5B$) according to Annex I of AWS D1.1M:2008). These are two common indexes used for estimating hardenability and susceptibility to hydrogen-induced cracking. “n.a.” is “not applicable.”

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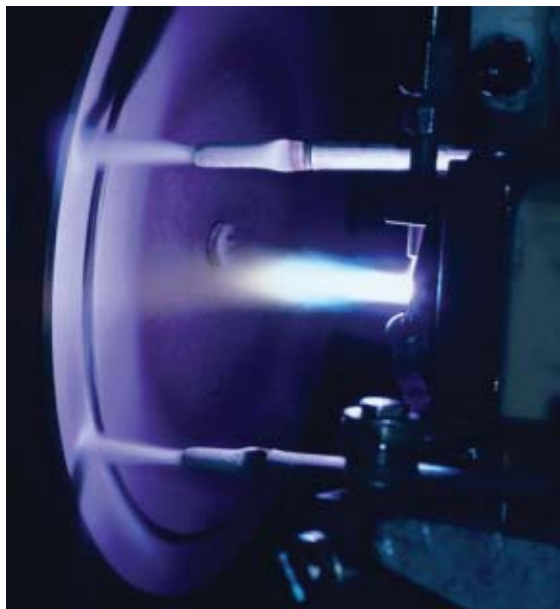
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Using Thermal Spray to Conserve Resources

Multiple applications depend on thermal spray for cost-effective and life-extending surface coatings

BY FRED VAN RODIJNEN

Modern industry is not only supplying very competitively priced, high-quality products, but now life cycle costs, including environmental and economic effects, are getting more and more attention. The focus from industry is frequently directed toward protection of our environment and conserving the resources on our planet. Thermal spray is a family of surface enhancement technologies with proven product features that address all of the mentioned demands.

Versatility of Thermal Spray

Since its invention by M. U. Schoop in the beginning of the 20th century, thermal spray has found applications in all kinds of industries. Unlike welding, where the base material is molten during processing, thermal spray is a so-called cold technology. The base material always stays below temperatures where heat effects start to take place. The coating thickness can vary from 25 μm (1 mil) to 25 mm (1 in.). Many of the metallic elements of the periodic table, as well as alloys and ceramics of these elements, can be sprayed and applied onto a surface as a coating.

Thermal spray can be used to restore worn surfaces, and in many cases, a coating material can be chosen that results in a higher wear resistance than the original substrate material. The majority of the applications are specified by the OEM, enhancing the features of a low-cost or light-

weight base material to enhance its use in highly demanding applications.

The following information offers an insight into the modern world of thermal spray coatings.

Thermal Spray Process

For all thermal spray processes, a coating material is melted using either a combustion or electrical (arc) heat source — Fig. 1. The liquid or molten coating material is then propelled by process gases and sprayed onto a base material, where it solidifies and forms a solid layer — Fig. 2.

OEM Applications

Automotive Cylinder Bore Coating System

A thin 150–200 μm (6–8 mil) plasma coating sprayed directly onto aluminum alloy cylinder bores eliminates the need for cast iron or composite cylinder liners — Fig. 3. The controlled porosity of the plasma-sprayed coating helps by significantly reducing the coefficient of friction through a microcavity lubrication system. This reduces the fuel consumption. Specially developed coating materials enable the use of bio fuels by providing resistance against aggressive corrosion. Fully automatic spray facilities can be integrated into any production setup — inline or cell. Prototype engines using this cylinder bore coating system operated for up to 400,000

km (250,000 miles) without need of repair. Following on this example, thousands of production cars have been manufactured using a plasma spray coating cylinder bore solution. This technology works for gasoline as well as diesel engines. The coating is also applied to high-performance race cars, go-karts, motorcycle engines, reciprocating aircraft engines, and heavy-duty diesel engines.

Thermal Spray Coating for Solid Oxide Fuel Cells

Presently, several hundred thousand solid oxide fuel cell interconnects like those shown in Fig. 4 are coated each year with an LSM (lanthanum-strontium-manganate) layer to prevent chromium evaporation from the metallic interconnect material. A technology to produce such coatings is atmospheric plasma spray using a Sulzer Metco TriplexPro®-200 spray gun.

The advantages of this technology are

- The ability to apply dense coatings with excellent reproducibility.
- High spray rates and deposition efficiencies.
- An absolutely constant process over a long period of time (200 hours of spray time without a drop in voltage).
- Minimal impurities in the coating coming from the electrodes and the nozzle of the plasma torch.

These LSM coatings are state of the

FRED VAN RODIJNEN is with Sulzer Metco OSU GmbH, Duisburg, Germany.

Based on a paper presented at the FABTECH International & AWS Welding Show held Oct. 6–8, 2008, Las Vegas, Nev.

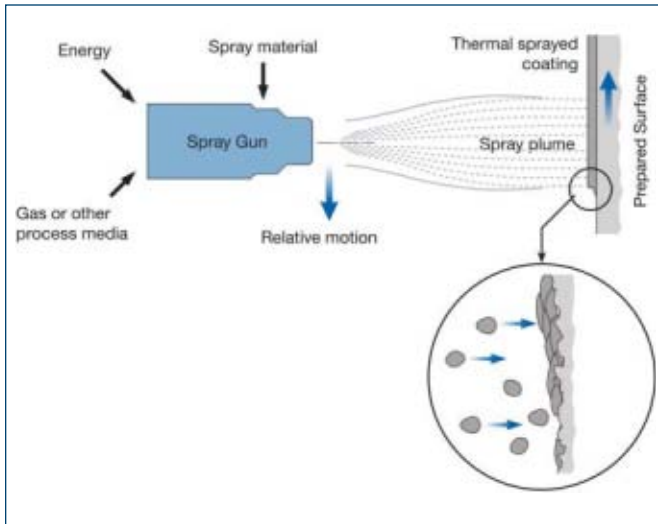


Fig. 1 — Principle of thermal spray.

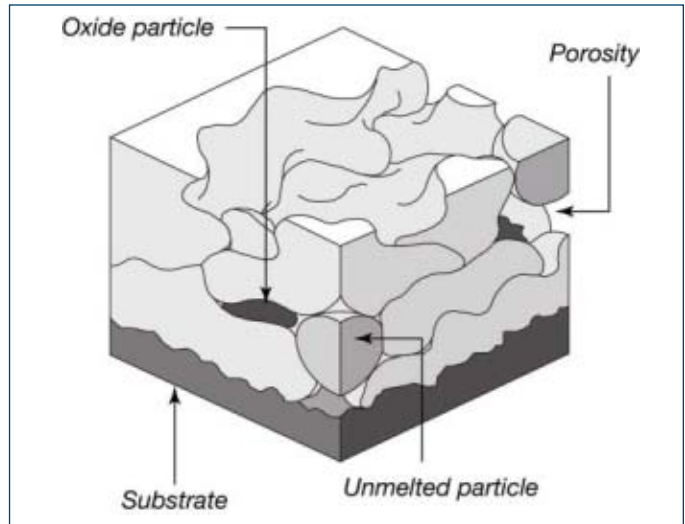


Fig. 2 — Schematic cross section of a thermal sprayed coating.

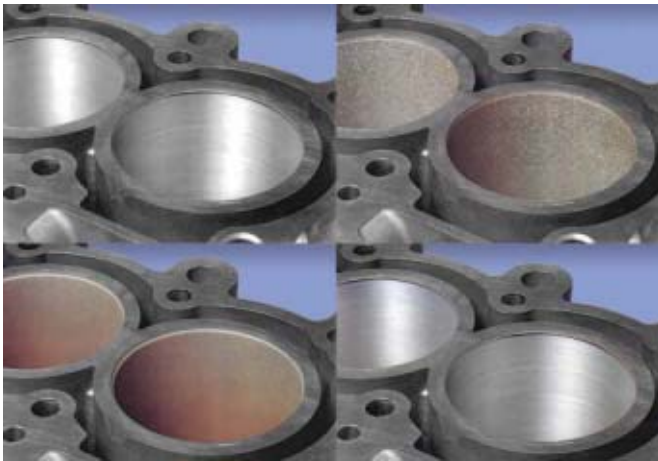


Fig. 3 — Cylinder bore. Clockwise: cast, premachined surface; surface prepared for coating; as sprayed; finish machined (using diamond honing.)

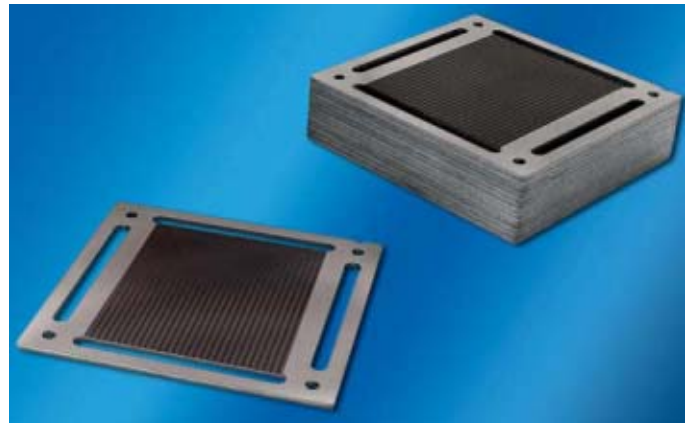


Fig. 4 — A few of the thousands of solid oxide fuel cell interconnects coated annually with thermal spray guns.

art, having a high-density applied coating thickness of approximately 50 μm and a relatively uniform coating thickness distribution as shown in Fig. 5.

The coating thickness is quite uniform, and it can be assumed that such a uniform coating thickness distribution can also be achieved on geometries that are more complex. By minimizing the coating thickness variation on the interconnect, the total coating thickness can be reduced. This decreases the quantity of coating material needed and reduces the processing time.

Thermal Spray Coating Solutions for Chrome Replacement

Because of growing requirements for environmental protection, plating shops are subject to ever tougher restrictions. As an alternative to hard chrome plating, a variety of thermal-sprayed carbide coatings can be used to provide wear and corrosion protection. To achieve corrosion resistance as close as possible to that of

chrome plate, the high-velocity oxyfuel (HVOF) process is used. The characteristics of HVOF coatings, in part, often exceed those of chrome plate; however, to obtain the reflective surface appearance of hard chrome plating, the carbide coating can be ground and lapped. An example application where thermal spray is used to replace hard chrome plate is that of landing gear components for airplanes. Figure 6 shows a WC/CoCr coated nose gear of an F5 Tiger.

Environmental Corrosion Protection Using Thermal Spray

A typical application that indirectly protects the environment and saves resources is applying sacrificial metallic coatings on steel structures and pipelines. The combustion wire process or electric arc wire spray process is used to apply zinc or aluminum alloys onto steel substrates — Figs. 7, 8. The applied coating thickness is 100 to 300 μm (4 to 12 mil). Alu-

minum and zinc coatings are anodic to steel, protecting the steel as a large sacrificial anode. The typical lifetime of a thermal sprayed aluminum (TSA) coating is 25 to 30 years. This life can be extended by increasing the coating thickness or adding a coating of industrial paint on top of the metalized coating. The thermally sprayed coating requires no maintenance throughout its entire life, although a painted top coat may require maintenance for cosmetic reasons. An additional advantage over organic coatings is that thermal sprayed coatings do not expose the environment to volatile organic compounds (VOC).

Restoration Applications

Coatings for Erosion and Corrosion Protection of Water Walls

Thermal sprayed coatings have been used successfully for several years as protective coatings in coal-fired power plants

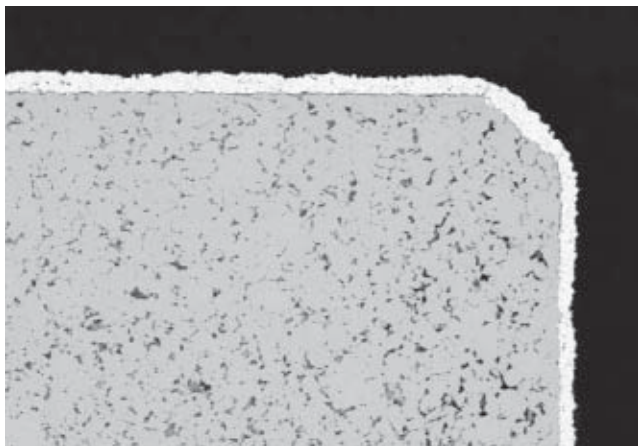


Fig. 5 — A state-of-the-art LSM coating, applied on an interconnect made out of P/M CrFeY, using atmospheric plasma spray.



Fig. 6 — Nose gear of an F5 Tiger with a WC/CoCr coating.



Fig. 7 — Arc spraying a T-joint with aluminum, 300 μ m (12 mil).



Fig. 8 — Combustion wire spraying a pressure gauge with aluminum, 300 μ m (12 mil).



Fig. 9 — Bearing shaft with a Babbitt coating.



Fig. 10 — HVOF coating of a sink roll.

to fight erosion problems that result from particulates in fuels and flue gases. As the variety of fuels used in power plants increases and the steam temperature in waste incinerators continues to rise to

achieve better energy efficiency and profitability, the need for efficient wear and corrosion protection in these facilities has gained in importance.

The material currently used to con-

struct boiler tubes is not sufficiently resistant to the complex combination of corrosion, erosion and abrasion to which these components are subjected. Material loss from these destructive processes of

Thermal spray allows designers to specify components made of readily available, less costly raw materials

up to 2 mm (0.08 in.) or more per year is not unusual.

Rebuilding a Bearing Shaft with a Babbitt Coating

The largest variety of applications for thermal spray coatings can be found in general machinery. Figure 9 shows a bearing shaft used in cement plants coated with a Babbitt coating. This special, particularly porous coating is designed for oil lubrication, providing a reservoir to prevent seizure. Other examples of applications are piston rings for diesel engines, piston rods in compressors, pump bearings, and valve covers.

Sink Rolls in the Steel Industry

The rolls used in the steel working industry must handle very heavy thermal loads of hot steel. In addition, slag from steel production must be reckoned with, and in zinc production, corrosive attack from the molten zinc. Several different coating systems have been qualified for use on both new parts and repair applications. Figure 10 shows the HVOF coating process of a sink roll.

Thermal Spray Technology Today

The first thermal spray application was performed 100 years ago. Nowadays, thermal spray technology has evolved into a surface-enhancing technology that is used by many industries worldwide, such as aerospace, automotive, electronics, medical, paper, and steel.

This coating technology allows application from thin, 25 µm (1 mil), up to thick, 25-mm (1-in.) coatings that improve component surface properties, change the functionality of a component's surface, or effect simple, low-cost repairs on worn and damaged surfaces.

Thermal spray technology provides coatings that help to save natural resources by refurbishing worn parts and protect against material loss due to wear, oxidation, corrosion, and other detrimental surface phenomena. Furthermore, thermal spray allows designers to specify components made of readily available, less costly raw materials, and apply surfaces with enhanced characteristics. By providing these advantages, thermal spray technology plays an important role in conservation and protecting our environment. ♦

Do You Have Some News to Share?

If you have a news item that might interest the readers of the *Welding Journal* readers, send it to:

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Who Chooses a Welding Career?



These nine people took a walk along the welding career path, but it led each down a different road

BY ANDREW CULLISON, MARY RUTH JOHNSEN,
HOWARD WOODWARD, AND KRISTIN CAMPBELL

To show the breadth of career opportunities available in welding, the *Welding Journal* editors interviewed nine professionals about their jobs and what it took for them to get to where they are today. Here's what they had to say about their careers in their own words.

AWS Certified Welder

James Whitehouse

I have worked as a maintenance rigger for "O" by Cirque du Soleil at Bellagio in Las Vegas since 2006 — Fig. 1. My job responsibilities entail maintaining the miles of wire rope and cables that suspend the scenery and enable the performers to fly. My job also entails rebuilding, replacing, and redesigning overhead rigging equipment. So, while my job description primarily states that I work with cable, the reality is that, because my show is now a little over ten years old, many of the original rigging systems have begun to degrade and it has become necessary to spend 75% of my time fabricating.

Not only do we deal with the age of the show, but we also have to combat the fact that the stage is actually a 1.5-million-gallon swimming pool that is corrosive to much of our scenery.

I first started welding when I was 13 years old in middle school, building sculpture. I was fortunate to have an art teacher who put himself through college as a welder in a shipyard. I worked building sculpture all through high school and learned gas welding and cutting as well as MIG welding and plasma cutting.

I am currently a sophomore studying mechanical engineering at University of Nevada Las Vegas. As far as welding education, most of what I know I learned through my art teacher and from the more experienced welders I have had the privilege of working with. When I was preparing for my welding tests for aluminum and stainless steel, I was instructed by Michael

Best, a CWI, of Nevada Compressed Gas.

As far as becoming an AWS Certified Welder, I had always wanted welding certifications in order to distinguish myself from other welders. When Cirque du Soleil gave me the opportunity to get certified, I fought for getting certified through AWS because of the fact that I would own the certification and the AWS certifications are nationally recognized.

I really enjoy welding, particularly for Cirque du Soleil, because no project is ever the same. Every project I have ever built has had its own challenges, whether they be in the material or the design, and as long as I can continue to learn from my projects, welding will continue to be interesting.

Although I have only been welding for 11 years, I feel that the most important aspect of becoming a welder is experience and the only way to gain experience is through working. So, take every opportunity to practice and learn from those you work with.

AWS Certified Welding Inspector (CWI)

Clifford (Kip) Mankenberg

I currently work for Shell International Exploration & Production, Houston, Tex., in a group responsible for the construction of offshore oil and gas production platforms — Fig. 2. In my present job function, I ensure that the contractors who build the company's platforms do this safely, making sure nobody gets hurt, and in accordance with specific contract documents. To a very large degree, these platforms are structural steel and piping projects. A great deal of the work I do is associated with structural steel and piping fabrication, welding, and inspection.

I have been in the welding field for almost 30 years and started out doing non-destructive examination (NDE). I received a diploma in nondestructive test-

Fig. 1 — James Whitehouse poses on the stage of "O" with the stainless steel contortion table he fabricated using the gas tungsten arc welding process. The table is stored underwater, in the pool, and put in place for the contortion act.

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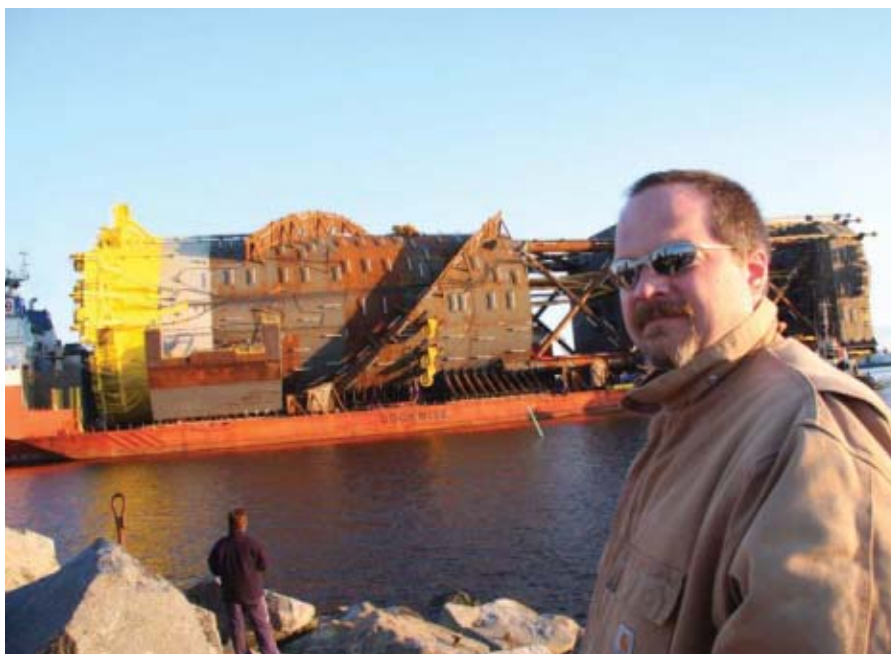


Fig. 2 — Kip Mankenberg stands in front of Shell's Perdido platform during transportation from its fabrication site in Finland to the United States. The hull portion of the platform, for which Mankenberg served as construction lead, is displayed. Due to its tall size, this had to be constructed sideways and upended once reaching the Gulf of Mexico. When installed only the yellow portion will show above the waterline.

ing technology from the Hutchinson Area Vocational-Technical Institute, Hutchinson, Minn., in 1982. I have worked in a number of different industries all over the United States and in many other countries around the world. Since 1991, I have worked primarily in the offshore industry.

Upon completing school, my first big job was on a commercial nuclear power plant under construction. I worked for the piping contractor and participated directly with people involved in many different disciplines including welding inspectors. To become a better NDE professional, I continued to study and learn all I could about welding. When I first heard about the American Welding Society Certified Welding Inspector program, I became immediately interested in obtaining this credential and thought it could help expand my horizons.

I first obtained my AWS CWI in 1986. Back in those days the program was smaller compared to now, and I did not attend a preparation seminar, but I studied long and hard prior to taking the exam. Fortunately, my schooling and work experience up until then had already given me a good start on the CWI body of knowledge and prepared me well for this test. I have been an AWS Senior Certified Welding Inspector (SCWI) since 1997.

I am still active in the world of NDE and maintain Level III certifications through the American Society for Nondestructive Testing in five methods — magnetic particle testing, liquid penetrant

testing, radiographic testing, ultrasonic testing, and visual testing.

It is tough to answer what I find best or most fulfilling about being a CWI. My experiences are colored by the particular projects and situations in which I have found myself, and it is not easy to separate out the strictly CWI part from the other aspects of the work or situation like having been overseas.

For most of my career, I have also been lucky to work with companies valuing the contribution a CWI can make. This comes from seeing welding inspection as not just a tool ensuring welding meets code requirements, but one that can be used to help continuously improve the welding and fabrication processes. In that sort of environment working as a CWI can be extremely satisfying for you are often the go-between amongst many different groups including fitters, welders, quality control, NDE, engineering, contractors, and owners. Your opinion and contributions are valued and even sought out.

One of the most challenging things about being a CWI is the amount of acquired knowledge needed to do the job right. The more I learn as a CWI, the more I realize that I do not know enough. What's more, I am involved in many other aspects of construction, not just solely performing welding inspections, and they all require learning and knowledge.

I usually give the same advice to individuals pursuing this certification: Search your soul and make sure you really want

to be a CWI. If you are certain, then it can be a truly rewarding career. But you have to be certain because it is difficult — you must be extremely ethical, knowledgeable, and always consistent in your actions. You may need to travel, work long hours, climb ladders and scaffolding, go inside of tanks, and so on. Plus, you will have to be willing to write detailed reports, keep logs, and continue learning over an entire career span. Know what you are getting into, and if it sounds worthwhile, then go for it.

Welding Products Salesman

Gene Lawson

After 35 years working for ESAB Welding & Cutting Products, a global company with approximately 8000 employees and 30-plus factories for equipment and consumables, I currently serve as a welding products salesman consultant in southern California and am semi-retired — Fig. 3. I represent ESAB products to manufacturers and end users from industries like power plants, shipyards, and wind towers. This encompasses welding machines and accessories, gas apparatuses, consumables, torches, tips, welding wires, and electrodes.

Factors that have helped me to succeed include training, practice, and most of all, preparation. A big part of my job is being knowledgeable about the products I sell, but it is important not to out-engineer an engineer. My position involves probing, discovering, and improving. Letting someone know what products will work for them has come with age and experience.

I joined this field from unrelated industries, first working in advertising then moving on to clothing sales. I decided to pursue industrial sales not only because I wanted a job with better potential, but I did not want to work weekends anymore. My career began in 1973 with Chemetron at its Denver, Colo., location. This company later became Alloy Rods, a welding division of the group, and is now a part of ESAB. When I started, I did not have a clue what the job entailed, and it was mind-boggling.

I soon discovered that I needed more education. I went back to college at the Metropolitan State College of Denver, Colo., and took welding principles, metallurgy, speech, and business classes. With this career change, I realized I should not be afraid to learn new things. I participated in training events offered by the companies I worked for — covering areas like distribution, principles of flux cored wires, and electrical machines — eventually even teaching some of these. In addition, I joined the American Welding Society where today I have earned a Life Membership.



Fig. 3 — Gene Lawson, a consultant who sells welding products for ESAB Welding & Cutting Products, is shown beside gas cylinders at a water pipe mill he recently visited to set up a new submerged arc welding process.

There is no one answer to any welding project, and that is what I enjoy about being a welding products salesman. There are too many to list like the process, power available, and gas type (or not). Each case is different. Ultimately, it is about finding the best products to suit particular needs.

If I am assisting a distributor, I will make a set route of calls and provide the necessary supplies required. However, when I am serving as a manufacturer's representative, I do a site visit to find out how that company operates, be of service by finding out their needs, and do long-term planning. If I see a benefit in a product that helps with production and efficiency, the customer can try using this or I will give clarification on specifications. When I am going into their turf, it is a different aspect of selling and sometimes hard to make things happen.

The job is endless and challenging...never boring. To realize I am contributing to things that matter such as constructing power plants, buildings, ships, and bridges is rewarding. And by selling products, I am proud to have a small part in helping accomplish these projects.

All in all, being a welding products salesman is a career of knowledge and relationships, both of which are great challenges. I cannot think of any other job that is so diverse. Welding covers a big scale from shops to refineries. I have helped distributors with their businesses, customers with their problems, and traveled to serve areas including regions west of the Mississippi along with the southwestern states.

The new AWS Certified Welding Sales

Representative program coming to fruition fulfills a personal goal of mine as AWS president last year. An individual who achieves this status will make employers and customers have confidence and credibility in what they can do.

You will only know if you are cut out for this job after several years. I have seen a lot of people who want to sell, and they burn out after a while. The welding industry is really a small fraternity — once a couple of years have passed, individuals do not tend to leave it and they make long-lasting friendships. The learning is more like osmosis...be patient!

AWS Certified Robotic Arc Welding Technician

Gregg W. Smith

I have been in robotics for 16 years. For the past two years, I have been senior manufacturing engineer at Harley Davidson, York, Pa. — Fig. 4. I have procured brand-new ABB robotic weld equipment for new processes and redeployed older ABB welding cells with new tooling. I have been a lead in setting up new robotic weld processes and providing documentation to support these processes. We also deal with troubleshooting robotic equipment to minimize production downtime.

Previously, I was a plant robotic welding engineer for Marada Industries, a division of Magna International Cosma Body Systems Div. While there, I obtained my AWS CWI certification.

I went into the Navy right out of high

school and was trained as an avionics technician. After being discharged, I went to Lincoln Technical Institute, Allentown, Pa., and received an associates degree in electronics technology. I worked as an electronics bench technician for three years and ended up getting laid off. I had maximized my earning potential as a technician and realized I needed a new path.

My father worked for Dana Corp. and talked me into applying for a job in robotics. I was apprehensive because I had no experience with industrial robots and knew nothing about welding. Dana was looking for technically sound people who could easily adapt to robots and they preferred people who did not have "bad" welding habits. I was trained to manually weld and had to pass a D1.1 weld test to support production. Dana had Motoman robots and I was sent to Motoman for training.

When I walked into Motoman for the first time I knew I wanted to work there. I was intrigued by the robots and knew that was my calling. After working at Dana for a year, Motoman had an opening in field service and I took the job. When you get hired by a robot company, you get months of training to support all of their product lines. Between the training and the five years of field service work I developed strong skills with automated welding systems.

Marada hired me as a welding engineer to support its plant of about 130 robots. Eventually I was asked to put together a full-blown training program to enhance the automated welding skills of the maintenance technicians in the various Magna divisions. To this day, it is the most rewarding part of my career. Since I had never provided training for groups of people before I found it both challenging and rewarding.

The most challenging aspect of what I do is to provide a robust process and solution for production. There are many aspects of robotic weld cell success. Optimizing cell cycle time and providing and maintaining a high level of weld quality is no small task. Robot cells can work very well with good operators and an efficient cell layout. Material in, material out, ergonomics, dimensional integrity, safety, training, and maintenance, all play a part in robot cell success. At times it can seem like the littlest thing can prevent an operation from running smoothly. Trying to engineer the proper solution for the operator can make or break the operation.

I have had my eye on the CRAW program since its introduction a few years back. It did not take off as quickly as I would have expected and I found it difficult to attend a prep seminar. I met a contract engineer at Harley Davidson who is a robotic professional. I noticed on his



Fig. 4 — AWS Certified Robotic Arc Welding Technician Gregg Smith oversees robotic arc welding operations at Harley Davidson, York, Pa.

business card that he was a CWI and a CRAW-T. This sparked my interest again and I asked him how he prepped and passed his certification. This past March I attended the prep class at Lincoln Electric in Cleveland, Ohio. My test was performed on a Fanuc robot with a Lincoln welder. The nice thing about the CRAW-T is that it applies to any robot and welder. It is testing your skill as a robot programmer along with your welding knowledge and ability.

There are still very few people in the industry who have the CRAW-T certification. I am now part of an elite group of people who have taken the time to prove their skill in robotic welding.

My advice is that if you want an ever-changing, highly technical, and rewarding job, and don't mind working in hot and, many times, dirty environments, then this could be a job for you. Programming robot

cells is as unique as the individual. You will only get better with time and experience. If you are persistent and wish to excel, you will find yourself being sought out by people who need help on a regular basis. This in itself can be very rewarding.

Welding Instructor

Ryan Eubank

I teach welding at three locations, Willoughby-Eastlake Tech Center, Lakeland C.C., and The Lincoln Electric Welding School in the Cleveland, Ohio, area — Fig. 5. Initially, I dwell on teaching shop safety and shielded metal arc welding basics because I have found most welding errors are made by ignoring these principles. After my students practice these essentials, I start teaching the more advanced welding procedures, destructive

and nondestructive testing methods, blueprint reading, air-arc gouging, basic fabrication and layout techniques, followed later in the course with troubleshooting tips and assignments to start the students thinking for themselves rather than just operating a machine. Later on, I introduce them to pipe welding and fitting using ASME and API codes. Many students certify to these standards in their senior year.

Admittedly, some of my students arrive as troubled teens who require very close monitoring to keep them attentive and motivated. One successful training method has been to divide the class into two groups, then I train each group on a different welding process. When each group is proficient in their procedure, I oversee as one group's members teach their process to the other group. This method not only develops the students' self-confidence levels, it builds camaraderie among all the class members. I also find the students respond well to the SkillsUSA competitions. We have been to the SkillsUSA state-level competitions three times. We won second-place twice and first-place honors on one occasion, then we went on to the nationals where we won third place. It was a motivating thrill for everyone.

I never intentionally trained to become a welding instructor. When I was 18 years old, I started my career on the factory floor at Lincoln Electric assembling and repairing welding machines. While there, I enrolled in the company's comprehensive 17-week welding program taught by Joe Kolasa and the late William West, who carefully groomed me to serve as an instructor in the program. Kolasa and West taught me how to teach by allowing me to "teach them" each day in order to prepare myself for presenting the next day's class. They reviewed my teaching style and gave me many tips for holding the students' interest that I use to this day. Later, I was offered an evening teaching job at a local vocational school that eventually opened the door for additional welding teaching opportunities.

My inspiration to continue as a welding instructor is the many former students who tell me how much they have benefited from learning welding skills and their appreciation for acquiring such a profitable trade. Since some of these students were previously thought to never amount to anything in life, these testimonials are impressive. Some came from broken homes with no father figure, so I became that father figure or the person they could talk to in order to plan out their life and dreams of becoming a successful citizen. I also have an added kinship with these students since I too had a learning disorder as a youngster. I recall teachers like Linda Clayton



Fig. 5 — Welding instructor Ryan Eubank (left) enjoys helping his students learn a profitable skill.

who took special pains to help me overcome dyslexia and learn to read in the second through fifth grades. Clayton assured me that I could learn, she said all students can learn, you just have to find the best way to teach them. As you can see, my inspiration continues every day as I see these former students succeed in life. That makes it all worthwhile for me.

I have found that the hardest part of teaching welding is tailoring the instruction for the more challenged students. Class members who lack reading, math, or other academic skills require more hands-on training and emotional support from the instructor. I must take a personal interest in each of these students and attempt to develop their self-confidence and interpersonal skills by having the students work together when possible. This tech-

nique may not be approved by some high school teachers, but it works for me. Since these students don't often get high grades, it is important to keep them motivated, wanted, and accepted with praise for each job well done.

If you are considering a career in welding education, you should be prepared to be patient and place others before yourself. You've got to want to interest the students in doing the jobs correctly, by stressing the basics of shop safety and following the rules to the letter. Welding educator can be a rewarding career, but it takes a special attitude to win the students' respect and instill in them the desire to succeed, so that they, perhaps for the first time in their lives, receive the education that works for them, and a skill that contributes to their financial security for life.

Welding Distributor

Gilly Burrior

As a welding distributor, my company, Florida Gas Welding Supply, offers Hollywood, Fla., area businesses with a wide assortment of industrial equipment, including welding machines, welder helmets, shielding gases, safety shoes, clothing, and consumables among numerous other product lines. We also provide a useful service to the community by listening to our customers' needs and offering guidance on what products would best fulfill their particular applications and suggestions on their most effective use.

What is most fulfilling about the business is that it is the realization of a dream come true for me and my family who worked together, not without conflicts, to succeed — Fig. 6. Initially, professionals in the field laughed at us for even thinking about entering the distributor business, since seed money for starting a distributorship is in the vicinity of a million dollars just for start-up inventory, etc. Happily, we ignored the naysayers and eventually founded a fledgling shop that managed to take hold and grow into a successful enterprise.

I and my family always wanted to have our own business but we had little in the way of resources except a strong determination to learn the trade and make it work.

Actually, at first, I set my sights on just opening a small automobile body repair shop in the Hollywood area. My first step toward this goal was to attend a trade school, where in 1980, I graduated as a certified automobile body technician. With little in the way of resources, my plan was to get a job and save enough money to open my own body shop. Fortunately, my first job was working for a welding supply company. During those several years I got to learn the business and like the activity. First hand, I met the customers and over time developed the expertise to help them solve their problems and suggest products to fulfill their needs. Another benefit of working for the welding distributor was I was able to purchase my personal welding equipment at a discount.

After numerous discussions with my family, where it seemed everyone had a different idea of what kind of business to enter and how to proceed, we decided on establishing a welding distributor store. All we had was about \$500 cash, and little knowledge of starting a business. Despite the grim outlook, we approached one of the larger gas manufacturers in the area to authorize us as a distributor. After much haggling, the manufacturer agreed to sell us industrial gases. It was a proud moment when we stamped our company name on the first five helium cylinders



Fig. 6 — Gilly Burrion (left) is shown with his brother, Otto, at Florida Gas Welding Supply, their family-owned welding distributor business in Hollywood, Fla.

“Florida Gas Welding Supply.” We had a lot of growing pains, but along the way we became a Hobart distributor, then received Miller training and became a Miller authorized distributor, then Uniweld of Ft. Lauderdale welcomed us as a distributor. Success seemed to build on success. The changes in South Florida industry have forced us to make changes, but we have adapted.

My advice to anyone thinking of entering the welding distributor business is to learn the business first. You will have to keep focused and committed on what you have to sell and not concentrate on just the “numbers.” You must have personal skills. Customers will return to a distributor they have confidence in, can talk to, discuss their concerns, and get good advice. There is no substitute for that kind of personal service. John Van Pelt, a Miller Electric employee who recently retired from the business, said, “It’s not just a sale, it’s what you give that customer after the sale.” Nothing beats helping someone by offering them help with hands-on techniques. In these uncertain times, our company’s goal is to stay alert, diversify, and be ready to take unexplored avenues. Right now, we are setting our sights on having our company certified as an AWS Accredited Test Facility. As the market changes, we will adapt.

I stay active in the local industrial field by meeting with welding professionals at the AWS South Florida Section meetings, where I serve as chairman. It’s been a rocky road at times, but in the end, I feel

that our business has made a meaningful difference in the South Florida welding community.

Welding Engineer

George Baldree

Since 2005, I have been working for Keppel-AmFELS in Brownsville, Tex., which is part of Keppel Offshore and Ma-

rine. We build and repair offshore drilling rigs and ships. I spent the previous 15 years working as a temporary engineer on projects large and small and traveling in the U.S., Canada, and Mexico. My goal during my temp years was to find a place I wanted to retire to and to use as many welding processes as possible. Brownsville, Tex., and the Rio Grande Valley is the place I found.

My father and grandfather were pipefitters and welders and I grew up in the shadow of nuclear construction projects. I was a bit of a firebug anyway and found heat transfer interesting. I met some welding engineers during high school and thought it would be a good career move. I enrolled at LeTourneau University. It took me ten years to earn my degree because of financial and family issues, but I finished it. I graduated from LeTourneau in 1986 with a BS degree in welding engineering technology.

What I like best about being a welding engineer is the problem-solving aspect for end users and fabricators. The most challenging aspect is the wide range of communication and the amount of educating that a welding engineer has to do on a daily basis. A welding engineer has to be able to communicate effectively with welders doing the work, their supervisors, other engineers, customers, and upper-level management. There is a lot of misinformation about welding in most organizations and everyone in the organization needs to be educated on the subject at some level.

Sometimes it seems that I have to teach everybody everything practically every day. Sometimes it’s the basics of welding, sometimes it’s an understanding of the



Fig. 7 — Welding Engineer George Baldree and Dr. Virginia Miller are shown with students in a Los Fresnos High School welding class. Baldree recommends that students who want to become welding engineers first learn to weld.

codes, sometimes its basic physics — the various, assorted aspects of welding. Communicating and educating is a huge part of what I do; handling problems as they come up.

I am also the chair of the new AWS Rio Grande Valley Section. I got involved with the Rio Grande Section formation because I saw the need for a forum where end users, suppliers, educators, and students can get together all in one room and just talk about welding. There are quite a few welding educators, businesses, and suppliers that to date have been working all by themselves. Now we have the ability to get together in the same room and just talk about issues, share information, and come up with solutions.

The AWS Rio Grande Valley Section was founded for several reasons. The first is that area members were tired of driving the 2½ hours one way to Corpus Christi for meetings. The second reason is to encourage our high schools and colleges to continue to establish top-notch welding training programs; the Rio Grande Valley has some of the best high school and college welding programs in the country both in quality and quantity — Fig. 7. The third reason is to serve the welding-related industries in the Rio Grande Valley with information and education and, of course, to advance the art and science of welding.

My advice for a young person who would like to be a welding engineer is, first, learn to weld. The skill will pay your way through school and you will learn a lot about the equipment and what can and cannot be done. Second is to be passionate about the subject. If you are not passionate about welding, my advice is to go find something that you are passionate about and do that. My third piece of advice is when that “what if” question pops into your head, form a hypothesis and test it using the scientific method. You never know what might be discovered.

Company President

Joe L. Scott

My present position is president, Devasco International, Inc., where most of my time is spent in the general management of the business, but I still find time to do some engineering on our projects — Fig. 8. Devasco designs, tests, manufactures, and markets engineered filler metals for unique or difficult welding applications. The products include cored wires, covered electrodes for ultrahigh-strength low-alloy steels, stainless steels, and nickel alloys. I, along with some partners, started the company 18 years ago.

The opportunity to strike out on my own came from what some might consider a setback. My employer at the time, Oer-



Fig. 8 — Joe Scott is shown working on a job for Conoco Phillips in Norway.

likon Welding Industries, went out of business in the U.S. Since I had no day job holding me back, I decided the time was ripe to start a business from scratch — nothing to lose in other words.

I am a welding engineering graduate from LeTourneau University. I chose the welding field rather than mechanical engineering or electrical engineering because welding embraces all of the scientific and engineering disciplines. Since graduating in 1976, I've worked for a variety of welding products manufacturers specializing in filler metal manufacturing, applications, QC, and marketing.

Welding has been a great experience for me because it is extremely varied in scope. I have been involved in aerospace, shipbuilding, power generation, oil and gas exploration, and transportation. I've also been a member of the AWS for 35 years.

After all these years, I still find the work challenging and exciting. Every product or project has to be analyzed for ultimate performance for the customer, verification tested, and profitable.

If you are analyzing welding as a potential career choice, the challenge, variety, and worldwide scope of this industry makes it a premier choice for anyone desiring challenge and the opportunity to make a difference.

Vice President Technical

Stanley (Stan) E. Ferree

I work for ESAB Welding and Cutting Products as the vice president technical. I'm responsible for the Research and Development (R&D) and Welding Application Departments for the North American operations. Our team develops new welding consumables and assists customers in their welding applications. ESAB is a global manufacturer producing consumables and equipment for welding and cutting applications for 105 years. I have been with ESAB for 32 years, including 15 years in my current position, and have worked in the welding industry for 43 years since 1966.

My career in welding started in the U.S. Air Force when I was selected to go to welding school to become a welder. At that time I had very little knowledge about welding. However, the technical training school provided a good background for developing my technical skills as a welder. I advanced through the various welder levels and training classes in the Air Force and became a fairly good “stick” welder.

After my discharge in 1970, I got a job at the McKay company as a R&D and Quality Control welder. I learned a lot in that job about the different types of cov-

ered electrodes, specifications, and welding techniques, and I soon became eager to learn more about the science and metallurgy of welding. My boss advised me to go to college and get a degree in welding metallurgy or engineering. He even agreed to let me work special hours so I could attend school. Fortunately, I could complete my first two years of a four-year degree at a nearby branch of Penn State University. So, with encouragement from my wife, I attended school part time while working a full-time job as a welder at McKay. It took five years to complete the courses at the PSU branch. I then had to quit my job to finish my degree at the main campus. I graduated with a BS in metallurgy in 1977 and started working as an R&D engineer for Chemetron/Alloy Rods, which is now ESAB Welding & Cutting Products. Throughout my progression from an engineer through various management roles, I attended AWS, ASM, and IIW seminars and conferences to continue my education. Although I'm now mostly involved with management responsibilities, I continue to develop new products and still weld in our lab.

I like the excitement and satisfaction that developing new products provide. Al-

Keep pursuing other areas of welding if one job is not fulfilling.

though I enjoy the technical side, I also like working with enthusiastic people who enjoy the challenges of new product development and assisting customers in complicated welding applications. I have also met some great people in the welding community throughout the world. My job has allowed me to present papers and learn about welding in just about every part of the world — from the U.S. to Russia, Japan, Korea, Australia, Europe, Scandinavia, Canada, and South America. I enjoyed meeting people of different cultures and sharing our common interests in welding and welding metallurgy.

The whole development process is quite challenging — selecting the correct projects, finding the technical solutions to develop them, and completing them on a timely basis. However, since most of our product development knowledge evolves from trade secrets and cannot be found in textbooks, we constantly need to experiment with different materials, formulations (recipes), and manufacturing processes to develop new products, which is the most challenging aspect of my job.

I think there are so many careers available in welding that I would not guide someone strictly to becoming a VP-Technical. However, the advice I would give applies to all of the various welding jobs. First of all, read articles about the various welding opportunities in our industry. Visit welding companies and trade schools to discuss welding-related jobs. Based on what looks interesting, start pursuing a goal — go to school (trade, four-year degree, two-year associate) and learn the basics. Then find a job that will advance your skills and knowledge about welding. Keep pursuing other areas of welding if one job is not fulfilling. Continue your education at all levels of your career, and don't forget to have some fun. ♦

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A detailed image showing a thermal spray process. A spray gun is applying a coating to a large, cylindrical metal component. Bright yellow and orange sparks are visible at the point of application. The component is mounted on a stand with rollers.

NEW DEVELOPMENTS IN THERMAL SPRAY COATINGS, PROCESSES AND APPLICATIONS

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Co\$t-Effective Thermal Spray Coatings for the Boiler Industry

A thermal spray coating can provide the long-term performance needed for the furnace cavity of coal-fired utility boilers retrofitted with low-NOx control systems

BY JUAN CARLOS NAVA

In 1990, the Environmental Protection Agency (EPA) passed the Clean Air Act amendments to regulate the emission of harmful gases, in particular nitrogen oxide (NOx) emissions. This legislation generated the advent of in-furnace NOx control systems introduced in one form or another by the major utility OEMs. Most of these low NOx in-furnace control systems limit the generation of thermal NOx by firing the fuel with lower amounts of oxygen than required for complete combustion. This is known as substoichiometric firing conditions. Under this substoichiometric firing condition, the carbon and sulfur present in the organic matter of the fuel can be released as CO(g) and H₂S(g). Additionally, a fraction of the noncombusted carbonaceous particulate arrives at waterwalls as unburned carbon together with unburned pyrite (FeS₂).

All of these “reduced form species” lead to severe attack of heat transfer surfaces by high-temperature oxidation-sulfidation mechanisms. Iron-based alloys are the primary choice for structural components exposed to sulfidation attack. Sulfidation attacks result in accelerated wastage rates, which lead to issues of unit reliability and availability. The cost of unscheduled outages can be extremely high for the power generator. There is a clear need to improve the serviceability of the current boiler fleet, to maintain continuous power generation, and to minimize the number of unscheduled outages.

Many technologies are currently used for the surface modification of components in industrial applications. Thermal spray coatings represent the most cost-effective of these technologies. There are

various innovative thermal spray technologies designed to deliver thermal spray surface layers of flexible compositions to meet customer requirements. This versatility in alloy chemistry represents another advantage for the use of thermal spray. This versatility was limited to powder-based technologies until the emergence of a method of manufacturing powder-core consumables of any imaginable alloy composition. This patent-pending manufacturing process from ArcMelt™, Bridgeton, Mo., increases the reliability of thermal spray coatings when applied using twin-wire arc technology. This method generates surface layers with characteristics similar to those obtained using more costly and cumbersome technologies such as high-velocity oxyfuel (HVOF) and/or air-pressure plasma spray (APS).

The Electric Power Research Institute (EPRI) conducted one of the most extensive field tests ever in the coal-fired utility market. A variety of surface modification products applied to waterwall test sections, including weld claddings, diffusion coatings, and thermal sprays, were tested and compared. The test was conducted in a wall-fired 550 MWE supercritical unit during the period from 1994 to 1999. The test results were documented in the EPRI report 1000186, *Long-Term Testing of Protective Coatings and Claddings at Allegheny Energy Supply Hatfield's Ferry #2 Boiler*. The objective was to identify the most cost-effective and reliable metallurgical coating to mitigate waterwall wastage in boilers retrofitted with in-furnace low-NOx control systems. The test panels were located in areas of

the furnace cavity where bare Alloy T-2 tubing was experiencing wastage rates as high as 60 mils (1.5 mm)/year. The fuel used in the unit was an eastern bituminous coal with an average 2.2 wt-% S and about 0.10% Cl.

Table 1 lists the thermal spray alloys used in this study. The top three alloys represent variations of the 50/50 Ni/Cr alloys known in the industry as 45CT.

Placement of the various surface modification products is shown in Fig. 1. Take notice that the temperature along the tubes increased from bottom to top, and from right to left. Figure 1 shows that the thermal spray compositions referred to as DS 469 and ZEDROX were placed in the most critical positions, as to the most probable locations for accelerated wastage rates. Figure 2 summarizes the material losses after 17,155 h (715 days) of service. The trend of the data suggested that the thermal sprays performed comparably to the weld claddings, and even better than the weld cladding alloy type IN 625. Table 2 directly compares the average thickness loss of the materials.

Although the results were favorable, the long-term projections fell short of the recommendations as shown in Table 3.

Unfortunately, there are several misconceptions in the marketplace concerning the applicability and the use of thermal spray coatings. Although no systematic study has been conducted to determine the limits of structural features in a thermal spray coating for industrial applications, the marketplace expectations of thermal spray coatings can be summarized as follows:

1. Low oxide content

JUAN CARLOS NAVA is with ME Technical Services. Additional information is available from ArcMelt™ Co., a subsidiary of CIC Group, Inc., Bridgeton, Mo., www.arcmelt.com.

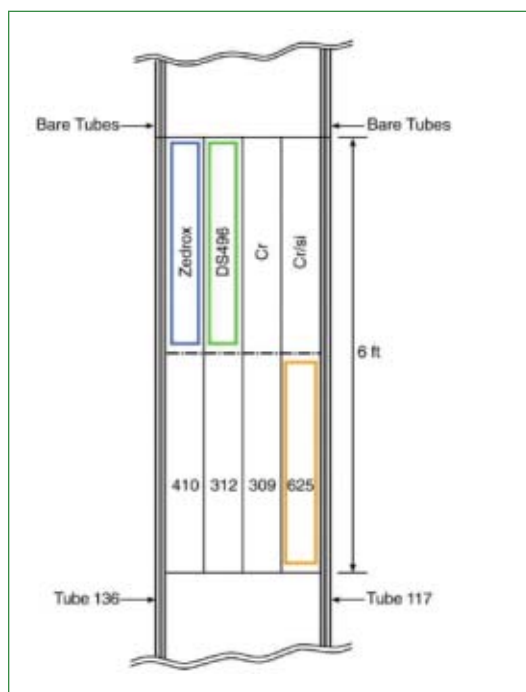


Fig. 1 — Location of the various surface modification products in the test panel.

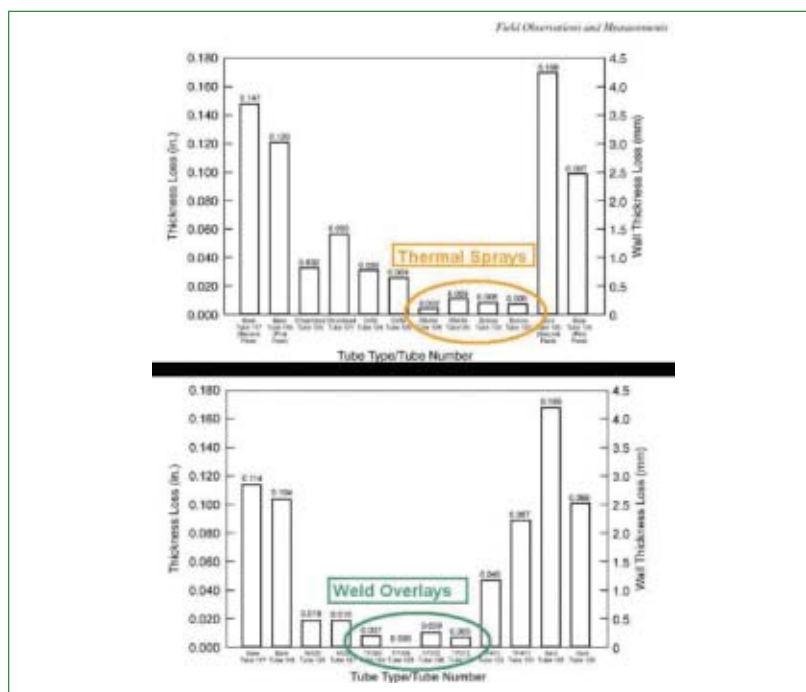


Fig. 2 — Wall thickness loss after 17,155 h (715 days) of exposure.

2. Low or no porosity
3. Bond strength in excess of 10,000 lb/in.²
4. Good match of thermal expansion coefficients.

These expectations kept the marketplace from seriously considering a cost-

effective thermal spray as a way to achieve reliable service for any reasonable length of time. Although a reduction in oxide content and porosity can be achieved with sophisticated powder-based technologies such as HVOF and APS, both of these technologies are designed for shop appli-

cation, and both are costly because of the low deposition efficiency. Also, these technologies are not reasonably practical for in-field repairs, which will be necessary regardless of the surface modification technology that is used.

ArcMelt™ AMC 3201 applied as a

Table 1 — Composition and Nominal Thickness of Coatings Installed during the Spring Outage in 1994

Coating Designation	Coating Composition (wt-%)							Nominal Thickness ^(a) mils (mm)
	Cr	Al	Si	Ti	Fe	Mn	Ni	
CT45 (wire arc) ^(b)	43.5	—	—	0.6	0.4	—	bal	20 (0.5)
13610 (wire arc) ^(c)	45	2.0	—	—	—	0.1	bal	20 (0.5)
DS 469 (HVOF)	42	—	2.0	—	—	—	bal	20 (0.5)
ZEDROX (wire arc, shop applied)	26	—	4	—	bal	—	—	20 (0.5)
Armacor X16	21	—	1.8	—	bal	1.0	6.5	20 (0.5)

(a) Actual thickness may vary ± 4 mils (0.1 mm).

(b) Prealloyed feed wire.

(c) Unalloyed feed wire.

Table 2 — Corrosion Rates at Centerline of Tube

Protective Coating	Thinning Rate, mils/year (mm/year)			Thinning Rate, mils/year (mm/year)		
	1st Pass Maximum	1st Pass Minimum	1st Pass Average	2nd Pass Maximum	2nd Pass Minimum	2nd Pass Average
None-Bare T2	85.8 (2.18)	14.2 (0.36)	53.3 (1.35)	135.9 (3.45)	9.7 (0.25)	75.8 (1.92)
TP 309 Stainless Steel	7.7 (0.20)	0.0 (0.0)	3.6 (0.09)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
TP 312 Stainless Steel	7.7 (0.20)	0.0 (0.0)	4.6 (0.12)	8.2 (0.21)	0.0 (0.0)	2.7 (0.07)
TP 410 Stainless Steel	27.1 (0.69)	17.4 (0.44)	23 (0.58)	54.6 (1.39)	36.3 (0.92)	44.3 (1.12)
Inconel 625	20.9 (0.53)	4.1 (0.10)	9.7 (0.25)	14.3 (0.36)	4.6 (0.12)	9.5 (0.24)
ZEDROX	3.6 (0.09)	2 (0.05)	2.9 (0.07)	3.1 (0.08)	1.0 (0.02)	2.4 (0.06)
DS 469	3.1 (0.08)	0.0 (0.0)	1.0 (0.02)	12.2 (0.31)	0.0 (0.0)	4.4 (0.11)
Chromized	37.8 (0.96)	1.5 (0.04)	16.2 (0.41)	66.9 (1.70)	5.1 (0.13)	28.1 (0.71)
Cr/Si	19.9 (0.50)	9.7 (0.25)	15.1 (0.38)	16.8 (0.43)	9.2 (0.23)	12.4 (0.31)

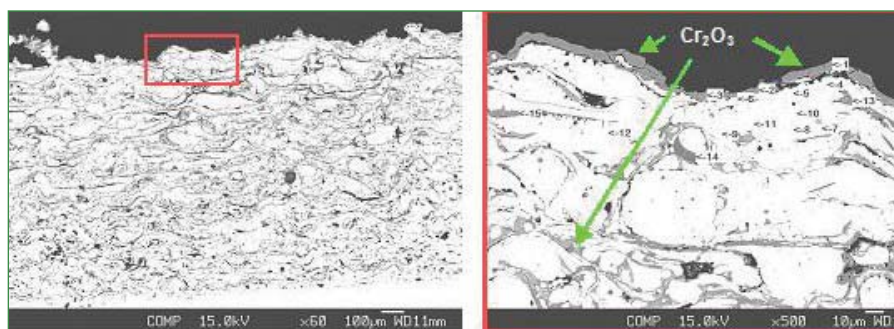


Fig. 3 — Oxidation resistance of AMC 3201 in still air at 816°C (1500°F).

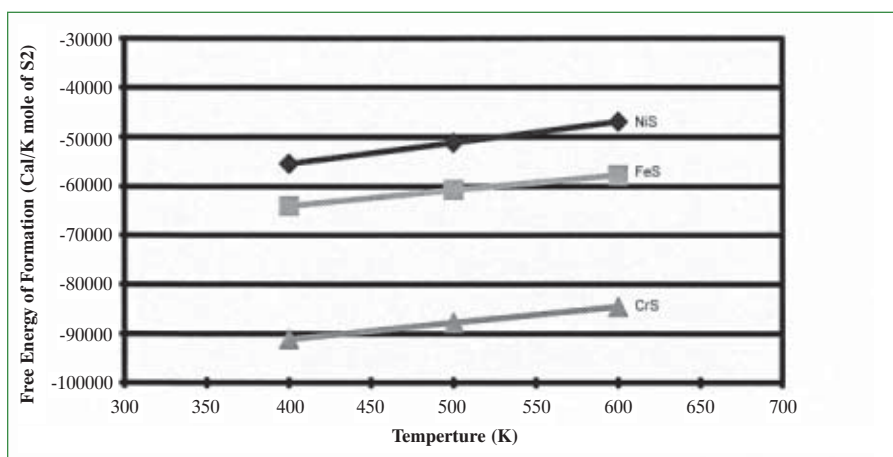


Fig. 4 — Ellingham diagram: free energy of formation of metal sulfides.

Table 3 — Relative Performance of Coatings and Weld Overlays Exposed for 17,155 Hours in Second Test Panel

Coating	Estimated Life (years)	Comments
Inconel 625	8–10	Highly variable coating thickness may impact total life expectancy. It appears that this nickel alloy is somewhat susceptible to sulfidation in this service environment.
ZEDROX	3–7	While generally good corrosion resistance was demonstrated, there is a distinct potential for local spalling and loss of protection. Need to further explore sulfur ingress through tight interstices in the coating. The sulfur progressed completely through the coating and was beginning to attack the underlying T2.
DS 469	3–5	While generally good corrosion resistance was demonstrated, there is a distinct potential for local spalling and loss of protection. Need to further explore sulfur ingress through gaps and other imperfections in the coating. The sulfur did progress completely through the coating and was beginning to attack the underlying T2.

thermal spray coating has a Cr content in excess of 25 wt-%. This consumable can be applied using the twin wire arc technology at rates in excess of 60 lb/h with minor modifications to the gun. This system results in a coating with an average 35% oxide content and low porosity in the order of 2 to 5%. The oxides are prima-

rily Cr oxides and the residual Cr content in the metallic splats is in the order of 30 wt-%. According to EPRI report 1014805, “obtaining acceptable lifetimes in oxidizing environments requires that a metal or alloy establish adherent oxide layers that act as a barrier between the aggressive high-temperature environment and the

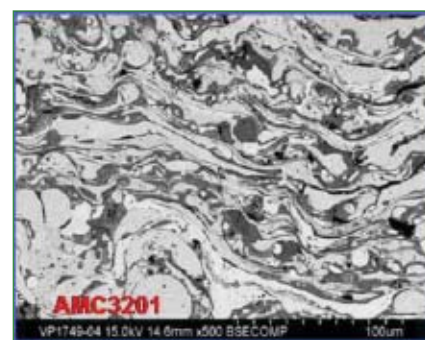


Fig. 5 — Backscattered image of the new coating.

underlying metal.” AMC 3201 forms continuous Cr-rich scale when exposed to still air at temperatures in excess of 800°C (1472°F) — Fig. 3.

When exposed to sulfidizing environments, the coating’s performance is expected to be equally high. Similar to the exposure in high-temperature air, the relatively low porosity in the coating will be sulfidized with the formation of Cr-sulfides sealing the coating structure from further gas permeation. Based on thermodynamic principles, Cr-sulfide in contact with a Fe-based metal will not result in Fe-sulfide attack that may undermine the bonding at the coating/base metal interface — Fig. 4.

The oxide network in the coating is different from that observed in conventional twin arc wire applications. The oxides are distributed more homogeneously throughout the coating thickness, which improves stress relaxation and minimizes residual stresses — Fig. 5.

During service, boiler waterwall components can experience fluctuations in temperature that may place the coating/base metal interface within the elastic tension-compression stress fields. To mitigate any issues of debonding due to thermal expansion coefficient differences, a Ni-rich base coat (AMC 4302) may be recommended.

The alloy has all the characteristics required for the long-term performance desired from a surface modification coating used in the furnace cavity of coal-fired utility boilers retrofitted with in-furnace low-NO_x control systems. Its Cr content also makes it applicable in other areas of the boiler. These areas include the convective paths, superheaters, and reheaters, where coal-ash corrosion and high-temperature carburization due to delay combustion of unburned carbon residue and high loss of ignition might be of concern.

Thermal spray coatings are a cost-effective and reliable material solution for the utility market. Thermal sprays are repairable. Even the best coating applied under the most stringent application qual-

ity controls will be susceptible to localized wastage due to the complexity and variability of the environments generated during the operation of the unit. However, in contrast to weld claddings, thermal spray coatings can be easily restored without compromising the integrity of the complete installation. Weld claddings can fail locally by a combination of waste and thermal fatigue. This leads to corrosion-induced fatigue cracking with unpredictable crack propagation rates. This may force plant operators to replace large sections. Many times these repairs cannot be completed during the scheduled outage.

The new coating can mitigate the effects of sulfidation in the waterwalls and in the convective paths of recovery boilers. Sulfidation and hot corrosion are also the major waste mechanisms in recovery boilers. The Cr content will slow down waste rates by forming a continuous, Cr-rich, slow-growing oxide that provides protection against further penetration. The pores in the coating structure, < 5%, will be sealed by a Cr-rich oxysulfide that is very stable. Debonding at the coating/base metal interface should not be an issue since the thermal expansion coefficient of the coating is similar to other Ni-base systems and to that of the low-alloy steel base metal. If the coating is required on a stainless steel component, a 5-mil-thick base coat of AMC 4301 may be recommended. Even if the Cr-oxysulfide formed in the pores is close to the coating/base metal interface, the thermodynamic analysis using the information provided in Fig. 4 indicates that sulfidation of the Fe-base alloy is unlikely.

Conclusion

The right alloy chemistry selection, combined with the coating structure delivered using the new core wire components, represent the best combination to provide a reliable metallic surface layer. The company's thermal spray coating system provides excellent oxidation and corrosion resistance, tolerance for thermal operation cycles, adequate adhesion, and cost effectiveness. ♦

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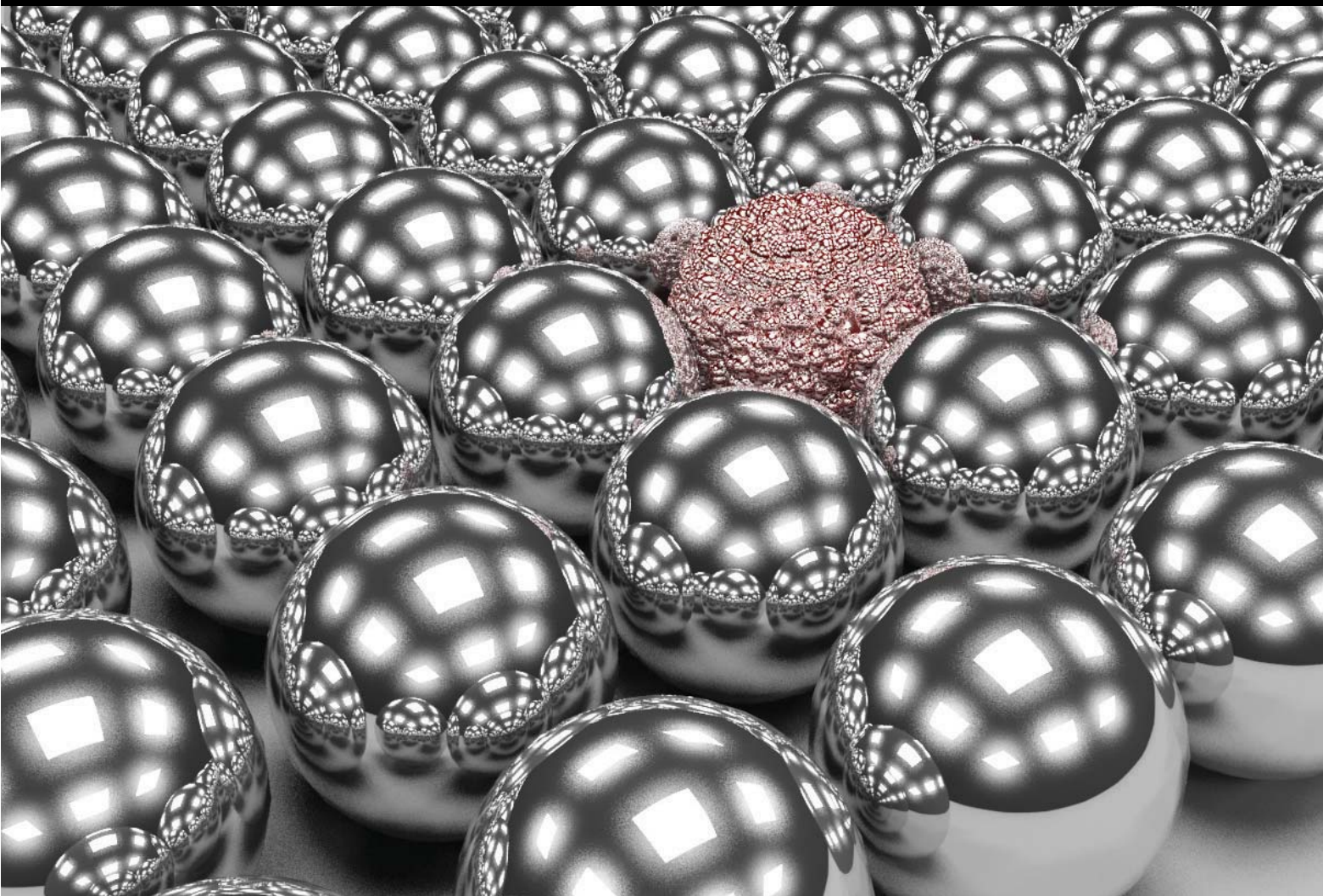
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The interest level is extraordinarily high when it comes to the welding of corrosion-resistant alloys. There are many reasons for this. One is the entry of the duplex stainless steels and other high-performance grades. Another is the unstable prices in nickel, molybdenum and titanium. When the price of nickel hit the roof, many fabricators switched from 316 to 201 stainless because of the latter grade's lower nickel content. Research is feverish throughout the world in the development of new and cheaper methods of producing titanium. Will a lower cost titanium make the metal more popular?

The overall activity is immense. Cladding and strip overlay processes have become more popular means of protecting parts exposed to heavy corrosion. Duplex stainless is now being welded for over-the-road tankage. New processes, like friction stir welding and the more

advanced thermal stir welding out of NASA will be discussed as well. Also, improvements in weld properties are being realized by increasing the weld interpass temperatures for conventional austenitic stainless steels.

Keep abreast of this exciting new world in welding where corrosion-resistant alloys have taken center stage. Mark your calendar for November 18, 2009, at the FabTech International and AWS Welding Show in Chicago, Illinois.

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Thermal Spraying Takes Center Stage at Summit

Here's a roundup of presentations given during the latest International Thermal Spray Association symposium

BY KRISTIN CAMPBELL

At the recent International Thermal Spray Association's (ITSA) technical program, various presenters brought forth an array of industry issues for professionals to learn about — Fig. 1. The event took place as part of ITSA's membership meeting April 16–18 at Disney's Coronado Springs Resort, Lake Buena Vista, Fla. It attracted about 50 attendees.

Then-ITSA Chair Marc Froning hosted the day-long conference. "This is our sixty-first year as an organization," Froning said, with headquarters based in Fairport Harbor, Ohio. The meeting represented Froning's last time serving as chair, for he has since moved on to ITSA's executive committee, and former Vice Chairman Dan Hayden has stepped up — Fig. 2. Froning also thanked Kathy Dusa, the organization's corporate secretary, for putting together the session.

Listed below are just a few features based on the numerous speeches that were made.

Technical Program Highlights

Jean Mozolic, president of The Mozolic Consulting Group, LLC, Wrentham, Mass., spoke about the world's largest democracy during **India — A Land of Cultural Diversity; A Land of Opportunity**. Automotive is one of this country's largest industries and a key sector of the economy; other important areas are aerospace and steel. "There's no regional or national thermal spray association," Mozolic said, but an India chapter of ASM International exists. The country's first thermal spray shop, Plasma Spray Processors, founded by Navin Doshi in 1984, has two locations in the Mumbai area. New joint ventures between India and the United States include Congress approving a United States-India nuclear deal where India agreed to open its civilian nuclear facilities to international inspection under the Nuclear Nonproliferation Treaty. "Right now, India by far is the premier country

for graduating metallurgists and material scientists," she concluded.

A Society of Manufacturing Engineers (SME) Overview by member and industry relations managers Tina Brudnicki and Deborah Robbins discussed this organization headquartered in Dearborn, Mich. Founded in 1932 with 33 members, it has grown to more than 25,000 members. "Our main focus is the sharing of manufacturing knowledge," Robbins said. Also, SME has several hundred webinars each year; publishes *Manufacturing Engineering®*; has a Jobs Connection network at www.sme.org; and offers various certifications and corporate training. Its Education Foundation sets out to attract and develop a future manufacturing workforce by inspiring, supporting, and preparing. "Last year we gave out about \$600,000 of scholarships, and this went out to 135 students," Brudnicki added.

Ernie Petrey with Ardleigh Minerals, Shaker Heights, Ohio, reviewed **Recycling of Filters from Dust Collector Systems**. "A number of things came together to

cause us to look at filters, and particularly filters from thermal spray operations," Petrey said. The three most prevalent recycling methods comingle all the metals so there is no way to recover those that have value. Therefore, the company thought of another way — Salvage All Value Elements (SAVE). "What we've tried to do is in a process that has a filter, is there material in the filter which can be salvaged?" he explained. Various parameters affect how the material gets treated. As a result, metals along with the filter's housing can be reclaimed.

A safety alert issued on April 14 by the **Thermal Spray Society Safety Committee** garnered attention from Larry Pollard of Progressive Technologies, Grand Rapids, Mich. He reviewed a recent thermal spray operator's fatal accident to evaluate what, if any, additional precautions can be taken to further reduce or eliminate risk of injury when using lathes. The results were as follows: The hand thermal spraying process and numerous other machining applications may involve close operational

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Fig. 1 — Speakers from ITSA's 2009 technical program, most of whom used interactive presentations, gathered for a group shot. Pictured in the front row (from left) are Joe Krall, Ernie Petrey, Tina Brudnicki, Julio Villafuerte, Deborah Robbins, Jean Mozolic, and Barbara Kanegsberg. In the back row (from left) are Robert Gansert, Lee Morgan, Dave Urevich, Steve Barker, Bob Unger, Robert C. Tucker Jr., Luc Pouliot, Larry Pollard, Marc Froning, Michael Molnar, and Lea Garrigan Badwy.

proximity to rotating work or components on lathes; the turning force produced by a lathe's head stock contains sufficient energy to draw an employee's clothing, jewelry, hand, arm, or entire body into the rotating mechanism, presenting a risk of serious injuries, amputation, or death; and each site utilizing lathes should conduct a detailed hazard analysis to identify the extent of unacceptable risks associated with its use of lathes and select appropriate means of controlling or eliminating them.

Cost-Effective Cleaning for Quality Thermal Spray Coating was the first of two topics by Barbara Kanegsberg, president of BFK Solutions LLC, Pacific Palisades, Calif. "We want to go beyond the conventional wisdom," Kanegsberg said, for getting rid of soil and dirt. "The challenge is to find the optimum process." Nearly all manufactured objects need to be cleaned, and the worker, environment, pocketbook, or product itself should not be harmed. Many options are available like solvent cleaning along with water- and solvent-based processes. Contamination categories include particulate (organic or inorganic), liquid, vapor, or biological. Functionality should be thought of with equipment washing, rinsing, and drying. The following were discussed as well: momentum processes, dry and nondry media, ultrasonic cleaning, acetone, bio-based and blended cleaning agents, and aqueous cleaning. Most household cleaners should not be used for critical applications — the additives can be inappropriate for

industry, and there could be unexpected formulation changes.

Kanegsberg's second talk covered **Regulations and Thermal Spray Beyond Cr VI+**. She spoke of a proposed listing status for cobalt-tungsten carbide powders and hard metals, the public comment hearing of which has now ended. "There are the issues of worker safety," she said, "the exposure to their chemicals and powders. It's how much an average worker can breathe. A high number is better for a permissible exposure limit (PEL)." The Occupational Safety and Health Administration sets federally enforceable PELs, and states can also set PELs that are legally enforceable in the state. Companies, the military, and attorneys pay attention to this matter. There has been a recent Department of Defense directive minimizing Cr VI+ use, too. Kanegsberg also suggested to keep aware with what is going on in terms of safety and environmental issues.

An **ASM Thermal Spray Society Certification Committee** assessment came from Luc Pouliot, vice-president, operations, Tecnar Automation Ltée, St-Bruno, Quebec, Canada. ASM's efforts included a survey identifying great interest for certification in the thermal spray industry; hiring a certification staff; plus forming and convening the certification committee to determine entry requirements, a candidate profile, and an exam. This committee has put together a detailed action plan to review and clarify objectives along



Fig. 2 — Marc Froning (left) presided over the thermal spray symposium on April 17th. He is shown with new ITSA Chairman Dan Hayden.

with roles and responsibilities. Starting the Job/Task Analysis is up ahead. "We like to believe that certification will significantly contribute to the shared objective of constantly bringing thermal spray to a better and better level improving quality and reliability," Pouliot said.

Bob Unger, a sales manager with Polymet Corp., Cincinnati, Ohio, discussed the first **New Developments in Thermal Spray Coatings, Processes and Applications Conference**. This conference, organized by AWS and ITSA, will take place Nov. 16 as part of the 2009 FABTECH International & AWS Welding Show including METALFORM in Chicago, Ill. It is intended to introduce the process and its uses to new potential users with sessions focusing on actual applications and new developments in thermal spray technology. Plus, it will include a half-day tutorial sponsored by ITSA on thermal spray fundamentals.

Robert Gansert, president of Advanced Materials & Technology Services, Inc., Simi Valley, Calif., talked about **Thermal Spray Business Trends, Markets and Emerging Technology**. "In review of the past two decades, the growth in the thermal spray industry has been very significant," Gansert said. As far as thermal spray trends in the industrial markets, aerospace demand is down, but considerable back orders still exist with original equipment manufacturers keeping many companies in this field busy. Newer technologies consist of laser cladding and cold spray while new materials are cryomilled and ultrafine. In more thermal spray developed countries, the thermal spray serv-

ice sector is roughly 70 to 80%. Also, the U.S. Department of Defense is implementing hard chrome replacement on applications for aerospace and landing gear. In fact, the defense industry is a customer to keep an eye on; thermal spray efforts involving platforms like aircraft and ships should see an increase. What's more, in the solar industry, thermal spray is used on wind turbines both for corrosion control and for the gear box.

ArcMelt...An Introduction, covered by Dave Urevich, the company's vice president, is a new ITSA member located in Bridgeton, Mo., built upon the concept of composite wire technology. It has developed tungsten-, chrome-, titanium-, molybdenum-, and iron-based alloys. The company also manufactures thermal spray and composite welding wires.

Thermal Spray Technology vs. Other Coating Processes received recognition from Robert C. Tucker Jr., The Tucker Group, LLC, Wesley Chapel, Fla. Coatings can increase equipment or process performance and efficiency, provide safer operations, reduced warrantee costs, and give a better appearance or higher perceived value. "You can produce higher quality products with a coated component," Tucker said. Coating functions serve as wear or corrosion resistance, plus offers aesthetic value. Advantages of

thermal spraying consists of depositing almost any metallic, ceramic, or cermet and many polymeric materials while disadvantages include line-of-sight deposition, porosity, and particle and gas velocity. These following issues were also discussed: chemical vapor deposition; physical vapor deposition; cathodic arc deposition; evaporation; sputtering; ion plating; coating microstructures; and abrasive, adhesive, and erosive wears. "In consideration of coating selections, you have to consider the total system, the purpose or the function of the coating, the component that you're going to coat, the environment that it's going to operate in, the coating properties, and the deposition properties," he emphasized. Technical and economic issues need to be analyzed as well. "Coatings provide many benefits and can actually be enabling in many processes," Tucker said. "Selecting the best coating for a given application is not a simple exercise."

Next Year's Get Together

ITSA's upcoming membership meeting is scheduled for April 2010 in San Francisco, Calif. To obtain more information about the organization, visit www.thermalspray.org or email itsa@thermalspray.org. ♦



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Thermal Sprayed Deposits Shield Structures from Corrosion

Corrosion protection depends on the alloys used, surface preparation, and application methods

BY DAVE WIXSON



Fig. 1 — An operator uses the arc spray system for applying zinc wire onto a support beam.

If materials are not corrosion resistant or covered by a protective coating, corrosion occurs quickly. Millions of dollars are spent every year to replace structures that have not received adequate attention to this matter. On the bright side, more than twenty years of corrosion control protection can be provided by thermal spraying steel structures. Using arc or flame spray equipment is certainly not a new process, but because of ongoing promotion, there is an increased interest for

its use in various applications. These long-life thermal spray deposits are used for corrosion protection of steel in rural, industrial, marine, and immersion services.

Aluminum, zinc, and 85/15 (zinc/aluminum) alloys provide both barrier and cathodic protection when applied in non-through porosity thickness — Figs. 1, 2. When cut through exposing the substrate steel, or when applied in a through porosity thickness, these thermal spray deposits will retard corrosion through cathodic

protection. They will also corrode in preference to the steel, continuing to protect the structure as long as it remains.

Typically, these thermal spray deposits are applied by a twin-wire arc or wire flame spray system. The arc spray systems operate by establishing and maintaining an electric arc between two wires that are fed through a spray head at a controlled rate. A low-voltage, high-amperage direct current power source is required to maintain the electric arc. In the flame spray process, a single wire is fed through the center of an oxygen-propane or oxygen-acetylene flame where it is melted — Fig. 3. In both processes, the molten metal is pneumatically propelled with compressed air and deposited on a prepared surface.

Alloys Normally Used for Corrosion Control

Aluminum, zinc, and their alloys are used for corrosion control with thermal spraying. These inorganic materials do not contain volatile organic compounds that can harm the environment. When zinc is alloyed with aluminum, the zinc-rich spray material forms an effective corrosion-resistant thermal spray deposit, having the attributes of both elemental components. Zinc's greater chemical activity provides greater cathodic protection than aluminum. Aluminum's lower chemical activity, adherent oxide film, and high resistance as compared to zinc provides longer term protection along with high-temperature and abrasion/wear resistance.

The selection of thermal spraying alloys should be based on the service envi-

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Fig. 2 — Close-up shot of an arc spray system placing 85/15 (zinc/aluminum) onto a dam gate.



Fig. 3 — A pipe section undergoes flame spraying. (Courtesy of Metallisation Ltd., Dudley, England, Steve Barker.)

ronment and the desired service life. The estimated service life for aluminum alloys is shown in Table 1 while Table 2 displays zinc and zinc/aluminum alloys (Ref. 1).

Surface Preparation

Because the thermal spray deposit is mechanically bonded to the steel substrate, surface preparation is the most critical step.

1. The steel substrate should be prepared to the following Society for Protective Coatings (SSPC) standards:

(a) SSPC-SP 5/NACE No. 1, *White Metal Blast Cleaning*, for marine and immersion service, or

(b) SSPC-SP 10/NACE No. 2, *Near-White Blast Cleaning*, for other service applications.

2. Surface finish and cleanliness should be confirmed according to SSPC-VIS 1, *Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning*.

3. The steel substrate should have, at a minimum, an angular profile depth of 2.5 mils with a sharp angular shape.

For more details, refer to Table 3 (Ref. 2).

Application Technique

Applying thermal spray deposits emits no volatile organic compounds, needs no drying time, and can be applied in low- and high-temperature environments.

The specified thickness should be applied in several crossing passes with each pass approximately 2–3 mils thick. Laying down an excessively thick spray pass increases the internal stresses in the thermal spray deposit and decreases its ultimate tensile-bond strength.

The thermal spraying gun should be perpendicular to the substrate to maintain the highest bond strengths. The spray

Table 1 — Estimated Service Life of Aluminum Thermal Spray Deposits

Environment	Coating Thickness Required for Service Life (μm) [mil]			
	5–10 years	10–20 years	20–40 years	> 40 years
Rural Atmosphere	—	—	50–200 [2–8]	—
Industrial Atmosphere	—	150–200 [6–8]	250–300 [10–12]	300 [12]
Marine Atmosphere	150–200 [6–8]	200–250 [8–10]	250–300 [10–12]	300 [12]
Seawater Immersion	200–250 [8–10]	250–300 [8–10]	300–350 [12–14]	—
Fresh Water Atmosphere	150–200 [6–8]	200–250 [8–10]	250–300 [10–12]	—
High Temperature (300°–660°C)	200–250 [8–10]	250–300 [10–12]	—	—

Derived from AWS C2.18-93, *Guide for the Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and Their Alloys and Composites* (Ref. 1).

Table 2 — Estimated Service Life of Zinc and 85/15 Zn/Al-Alloy Thermal Spray Deposits

Environment	Coating Thickness Required for Service Life (μm) [mil]			
	5–10 years	10–20 years	20–40 years	> 40 years
Rural Atmosphere	—	75–125 [3–5]	150–200 [6–8]	250–300 [10–12]
Industrial Atmosphere	—	150–200 [6–8]	300–375 [12–15]	350–400 [14–16]
Marine Atmosphere	—	250–300 [10–12]	300–375 [12–15]	350–400 [14–16]
Fresh Water Atmosphere	150–200 [6–8]	250–300 [10–12]	300–375 [12–15]	—
Potable Water		250–300 [10–12]	300–375 [12–15]	—
Seawater Immersion	250–300 [10–12]	350–400 [14–16]	—	—

Derived from AWS C2.18-93, *Guide for the Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and Their Alloys and Composites* (Ref. 1).

Table 3 — Additional Information on Surface Preparation

Thermal Spraying Material	Process	Blasting Media ^(a)	Size ^(b)
Al, Zn, 85/15	Arc Wire and Flame Wire	Aluminum Oxide Angular Steel Grit Copper and Nickel Slag Almandite Garnet Chilled Iron Grit	10–30 Mesh G-16 to G-24 G-16 to G-24 G-16 to G-30/40 G-16 to G-40

a. All blasting media should be dry and free of all oil/grease, fines, and materials not allowable in the blasting media material specification.

b. Select mesh size appropriate to the anchor-tooth depth requirement and the blasting equipment used. Derived from AWS C2.23M/C2.23:2003, *Specification for the Application of Thermal Spray Coating (Metallizing) of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection of Steel* (Ref. 2).

Table 4 — Minimum Tensile-Bond Requirements (per ASTM D4541 using a self-aligning portable test instrument)

Feedstock	lb/in. ² (MPa)
Zn	500 (3.45)
Al	1000 (6.9)
85/15	700 (4.8)

gun stand-off distance should be 6–10 in. from the substrate. If the spray head is farther away from the substrate, more of the thermal spraying material will not be applied and instead will drop off in the form of dust. An excessive spray distance will also decrease the bond strength of the thermal spray deposit.

In addition, the thermal spray deposits should be applied in a block pattern, typically 3 × 3 ft. Each spray pass should be applied parallel to and overlapping the previous pass by about 40%. Successive thermal spray deposits should be applied at right angles to the previous ones until the specified thickness is attained. This method is preferred to achieve the most uniform thickness and best possible condition.

Quality Assurance Steps for Thermal Spraying

Three types of testing are commonly conducted on corrosion control thermal spray deposits. These methods are tensile bond test, bend test, and cut test.

Tensile Bond Test

The tensile bond test, in accordance with ASTM D4541, *Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers*, is done by using a self-aligning portable adhesion test instrument or equivalent. The minimum tensile bond value may be specified according to Table 4.

One portable tensile-bond measurement should be made about every 50 m² (538 ft²). If the tensile bond is less than

the contract specification, the degraded thermal spray deposit should be removed and reapplied.

For nondestructive measurement: Tensile force should be measured to the contract-specified tensile. The tensile force should then be reduced and the tensile fixture removed without damaging the thermal spray deposit.

Bend Test

The bend test (180-deg bend on a mandrel) is used as a qualitative test for proper surface preparation, equipment setup, and spray parameters. The bend test puts the thermal spray deposit in tension. The mandrel diameter for the threshold of cracking depends on the thermal spray deposit thickness.

1. Use a carbon steel coupon approximately 2 × 4 to 8 × 0.05 in. (50 × 100 to 200 × 1.25 mm).

2. Prepare surfaces per contract specification.

3. Spray 7–10 mils of material on the coupon, approximately 2 mils per pass.

4. Bend coupons 180-deg around a 0.5-in.- (13-mm-) diameter mandrel.

The bend test passes if, on the bend-radius, there is (a) no cracking or spalling or (b) only minor cracking that cannot be lifted from the substrate with a knife blade.

The bend test fails if the thermal spray deposit cracks with lifting from the substrate.

Cut Test

The cut test consists of a single cut, 1.5 in. long, through the thermal spray deposit to the substrate. The bond shall be considered unsatisfactory if any part of the thermal spray deposit along the cut line can be lifted from the steel.

Conclusion

Thermal spraying has become a worldwide, cost-effective solution for long-term

corrosion control protection of steel structures. Power-generating windmill towers and components, bridge structures, wharf pilings, grandstand structures, light poles, ornamental iron, and bridge expansion joints are but a few examples of projects calling for corrosion control using thermal spray deposits. ♦

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Nano Powders Improve Wear Resistance of Coatings

Consolidated forms of near-nano and nanograined materials are stronger and harder than consolidated forms consisting of conventionally sized thermal spray materials

BY C. MELNYK, S. SCHROEDER, D. GRANT, G. SAHA, L. GLENESK, AND R. GANSERT

Nano- and near-nanostructured materials are now being used in a variety of industries from energy to sports and recreation. In fact, California Nanotechnologies, Inc., Cerritos, Calif., had nanograined structural components used in the 2008 Beijing Olympics.

Organizations around the world are developing and implementing a wide range of materials and applications for nano- and near-nano materials in the thermal spray field. Candidate thermal spray processes include plasma, wire arc or flame spraying, and high-velocity oxygen-fuel (HVOF) deposition, as well as cold-spray techniques. Figure 1 illustrates the HVOF process. Applications range from ceramics for biomedical uses (Refs. 1, 2) to superalloys intended for aerospace and industrial gas turbine applications (Refs. 3-5) to carbide-based materials for wear applications (Refs. 6-9). Nanostructured materials offer the potential for significant improvements in material properties.

The Hall-Petch relationship cites the strengthening of materials by reducing the average crystallite (grain) size (Refs. 2,



Fig. 1 — HVOF spraying of nano- and near-nano based materials.

10). In terms of yield strength and hardness, the expressions are given as

$$\sigma_y = \sigma_0 + k d^{-1/2} \quad (1)$$

$$H = H_0 + k' d^{-1/2} \quad (2)$$

where σ_y and H refer to the yield strength and hardness of the material, respectively, d is the grain diameter, and k and k' are constants unique to each material. Equa-

tions 1 and 2 show that when reducing grain sizes from the micron scale to the nanoscale, the mechanical strength of the materials increases significantly.

Powder consolidation methods including hot isostatic pressing and spark plasma sintering provide a useful baseline for understanding the potential of nano- and near-nano materials. These bulk techniques provide a more homogeneous microstructure than from a surfacing technology (thermal spray) for evaluating the properties as predicted by the Hall-Petch relationship. By examining the nanocrystalline powders in bulk consolidation, we may better understand the potential of these nanocrystalline powders for thermal spray application. The results of consolidated forms of nanocrystalline materials are compared to consolidated forms of virgin (micron scale) grains to observe the improvements in properties capable with using nanograined materials. Coatings are then produced using nanocrystalline WC-17Co powder and microcrystalline WC-10Co-4Cr powder and compared.

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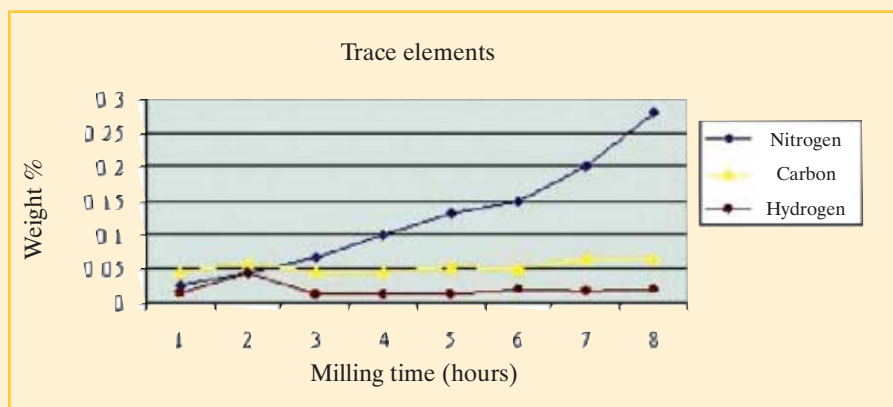


Fig. 2 — Nitrogen wt-% vs. milling time (Ref. 13).

Cryomilling-Produced Nanocrystalline Materials

Several organizations involved with structural materials have produced nanocrystalline materials by cryomilling (Refs. 11, 12), as have organizations involved in the thermal spray industry (Refs. 3–5). This method has been used to produce nano- and near-nanocrystalline powders for hot isostatic pressing (HIP), spark plasma sintering (SPS), and thermal spraying.

In cryomilling, the nanomaterials are produced by milling conventional feed-stock material in a cryogenic environment. Cryomilling a metallic powder in liquid nitrogen provides grain refinement as well as the potential formation of nitrides. Figure 2 shows the increase in nitrogen content in an Al-Mg-based alloy as a function of the milling time (Ref. 13). The hydrocarbon content remains unchanged during the milling process.

Figure 3 shows a transmission electron microscopy (TEM) image of an aluminum-nitride (AlN) grain formed by cryomilling with dimensions of less than 10 nm (Ref. 13).

The properties of the original (virgin) materials are significantly improved through the use of the cryomilling process. The grain refinement and introduction of nitrides strengthens the material considerably. As shown in an Ashby Map in Fig. 4, a cryomilled Al-Mg-based alloy exhibits the specific strength and specific stiffness of a titanium-based alloy (shown at intersection on map). Similarly, the cryomilled Al-Mg-based alloy enables a much higher service temperature than a conventional Al-Mg alloy.

Experimental Approach

Series 1100 aluminum, commercially pure (CP) titanium, tungsten carbide-10

wt-% cobalt-4 wt-% chromium (WC-10Co-4Cr) and tungsten carbide-12 wt-% cobalt (WC-12Co) are cryogenically milled in a Model S1 Szegvari mill from Union Process, Akron, Ohio, that was modified for liquid nitrogen use. Stainless steel balls are used as milling media at the appropriate ball-to-charge ratio for a given material. A 30:1 ratio of ball to charge is common for milling metallic powders. The milling media and ball diameter are established according to the powder to be milled. Table 1 provides the representative variables that are established for a given cryomilling run.

Hot Isostatic Pressing and Spark Plasma Sintering

Nano- and near-nano grained materials produced using cryomilling are subsequently processed using hot isostatic pressing or spark plasma sintering to consolidate the powders into a bulk product. The processing parameters for hot isostatically pressing CP titanium are provided in Table 2.

Spark plasma sintering (SPS) is conducted using a Dr. Sinter Lab™, Model SPS-515S from Syntex Inc., Kanagawa, Japan. In SPS, powder is placed in a graphite die and pressed uniaxially while a pulsed electric current is applied through graphite punches — Fig. 5. In this experiment, the graphite die produced disks 20 mm in diameter by 6.6 mm in height. A Type-K thermocouple is inserted into the die wall to monitor and control temperature.

Sintering parameters for SPS are provided in Table 3 for the experiments used for virgin and cryomilled Al and cryomilled WC-12Co, respectively.

Thermal Spray Processing

High-velocity oxygen-fuel (HVOF) spraying of nanocrystalline and microcryst-

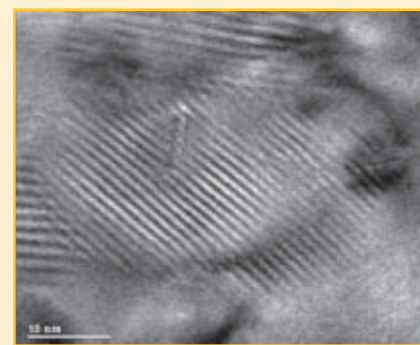


Fig. 3 — TEM image of aluminum nitride (AlN) formed in cryomilling of an Al-Mg-based alloy (Ref. 13).

Table 1 — Typical Cryogenic Milling Parameters

Element	Parametric Value
Powder weight (kg)	1 kg
Milling time (h)	5 h or greater
Ball-to-weight ratio	30:1
Speed rev/min	180 rev/min or greater

Table 2 — Hot Isostatic Pressing

Element	CP Ti
Consolidation temperature (°C)	815
Consolidation pressure (MPa)	69.0

Table 3 — Spark Plasma Sintering

Element	Al 1100	WC-12Co
Temperature (°C)	515	1025
Pressure (MPa)	47	48.6
Time at temperature (min)	5	10

talline powders was carried out at Hyperion Technologies Inc., Calgary, Alberta, Canada. Nanocrystalline WC-17Co (Powdermet PCompP™) and microcrystalline WC-10Co-4 Cr (Metco SM 5847) powders were sprayed using a Model DJ2700 HVOF system from Sulzer Metco, Westbury, N.Y. The coatings were sprayed at a traverse speed of 0.2 m/s, and deposited at a thickness of 5 microns per pass. The HVOF spray parameters are provided in Table 4.

Microstructural analysis was performed in-house using a JSM-7000F field emission scanning electron microscope from JEOL, Tokyo, Japan. Microhardness was measured using a Model S140 hardness tester from Struers, Copenhagen, Denmark. A 300-g load was used for the aluminum samples, and a 1000-g load was used for the titanium and tungsten carbide-cobalt samples. Rockwell hardness

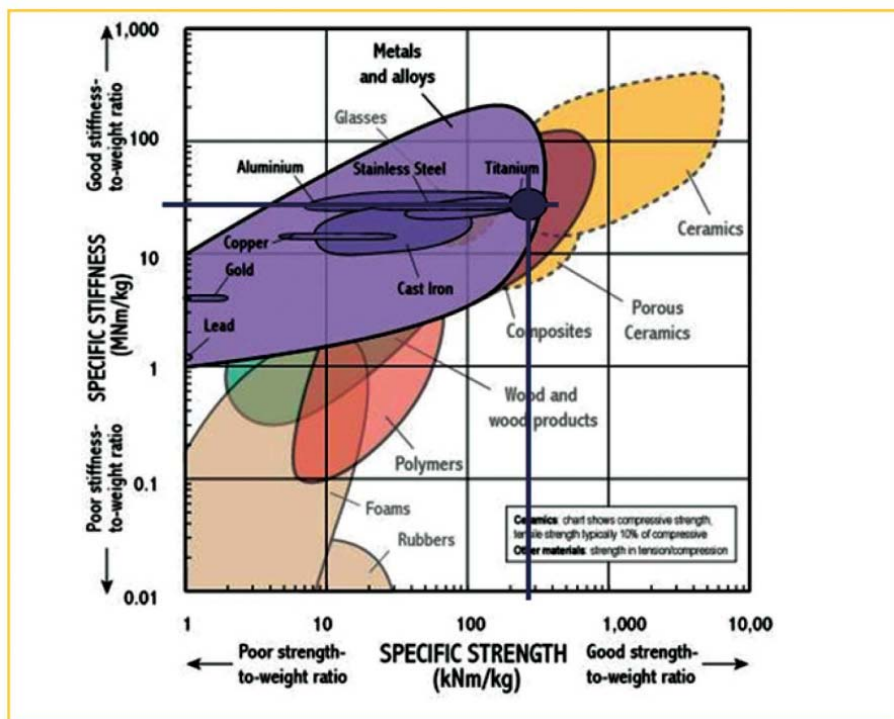


Fig. 4 — Specific strength and specific stiffness of a cryomilled Al-Mg-based alloy (Ref. 13).



Fig. 5 — The spark plasma sintering operation.

Table 4 — HVOF Spray Parameters

Element	Parametric Value
Shroud gas, air (slpm*)	1742
Oxygen (slpm)	1346
Methane (slpm)	918
Carrier gas, nitrogen (slpm)	60
Spray distance (cm)	23
Spray rate (g/min)	38

*Standard liters per minute

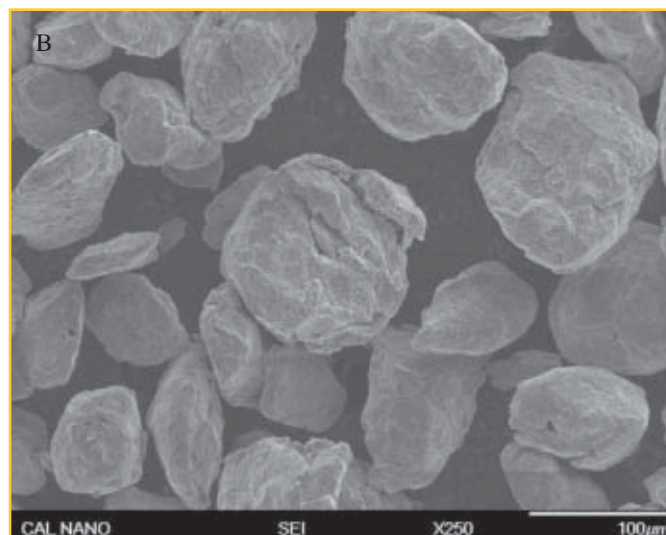
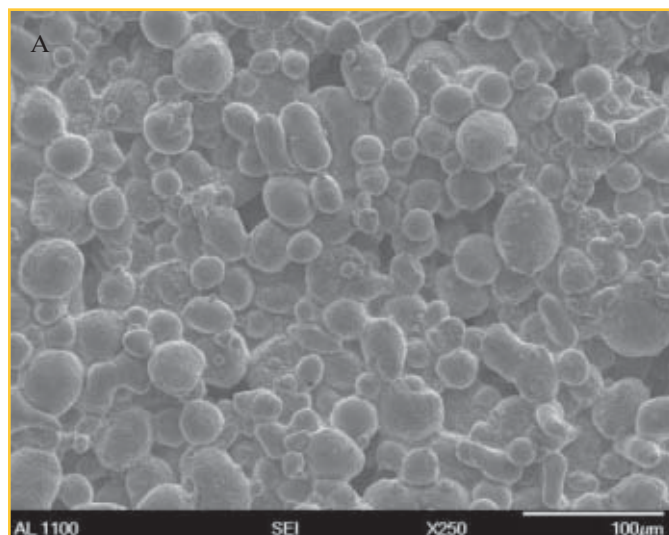


Fig. 6 — SEM images of the following: A — Series 1100 Al virgin powder; B — cryomilled powder after 8 h.

measurements were conducted using a Model 2001R tester from Instron, Norwood, Mass. Hardness measurements were carried out by taking a minimum of five indentations on each specimen. Shear testing was conducted using an Instron Model 5590 Satec system, using a single shear test fixture. Sliding wear resistance of thermal spray coatings was evaluated using a reciprocal pin-on-plate wear tester, following ASTM Standard G133-05.

Results and Discussion

Powders

Scanning electron microscopy (SEM) images of the virgin and cryomilled powders of aluminum and CP titanium are shown in Figs. 6 and 7.

Grain refinement along with the formation of nitrides occurs in aluminum and CP titanium powders. A layered structure

is formed in the agglomeration (e.g., microwelding) of the milled material. Nano- and near-nano grains are produced in these layers. The agglomerated powder particles are micron size in scale (e.g., 10–100 microns) consisting of nano- and near-nano grains.

Cryomilling of ceramics and conventional ceramic-metal (cermet) powders results in attrition milling of the particles to nano- and near-nano grains without the

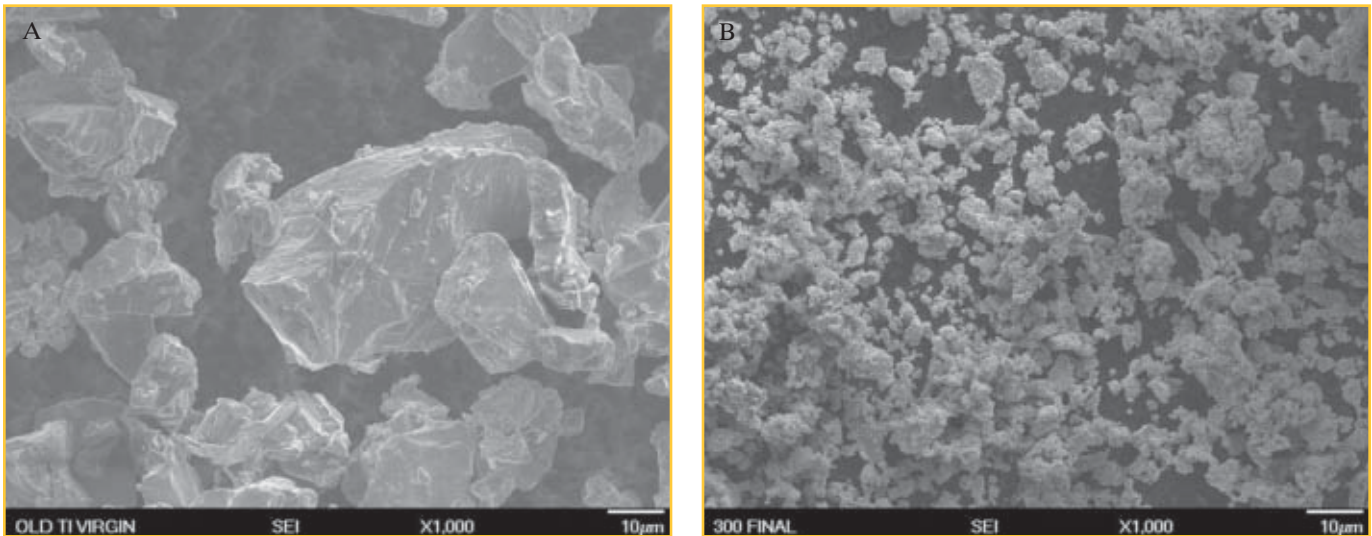


Fig. 7 — SEM images of the following: A — CP titanium virgin powder; B — cryomilled powder after 8 h.

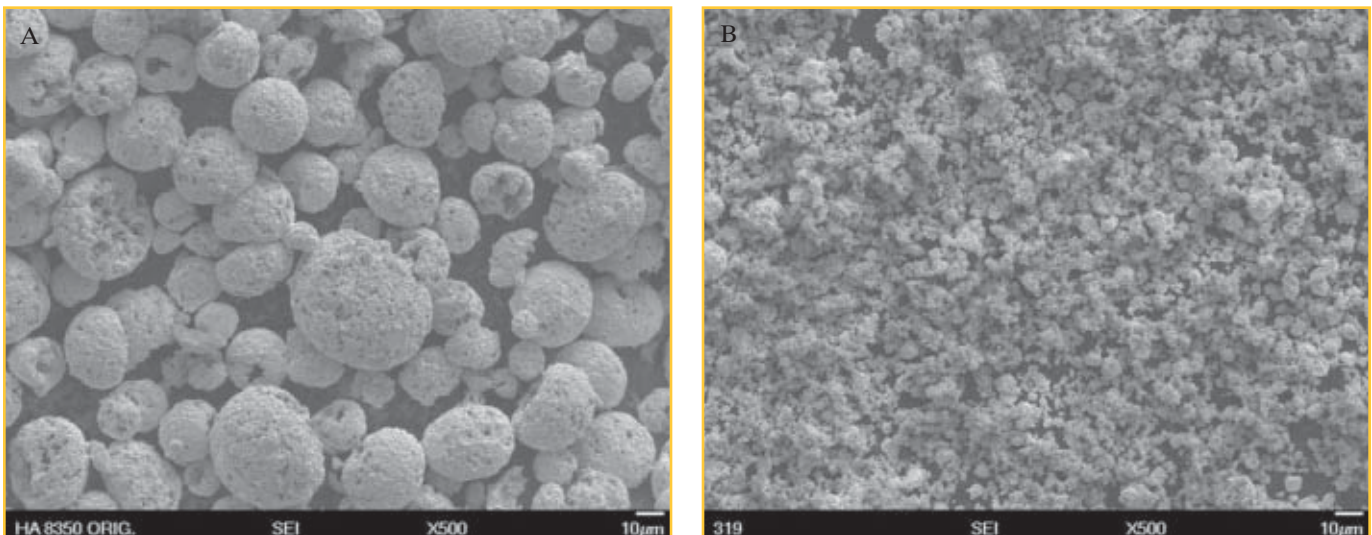


Fig. 8 — SEM images of the following: A — WC-10Co-4Cr virgin powder; B — cryomilled powder after 12 h.

characteristic agglomeration observed in the metallic particles. SEM images of WC-10Co-4Cr powder before and after cryomilling are shown in Fig. 8.

Hot Isostatic Pressing

The results of the cryomilled CP Ti powder hot isostatically pressed are provided in Table 5.

Commercially pure titanium, Grade 4, has a reported tensile strength of 550 MPa (80.9 ksi) (Ref. 14). The ultimate shear strength of cryomilled CP titanium was found to be 648.1 MPa (94.0 ksi) (Ref. 15). This is higher than the tensile strength referenced for CP Ti, Grade 4. As the shear resistance of titanium has been referenced as 80% of the tensile strength (Ref. 14), we may expect the tensile strength of the

cryomilled CP Ti to be considerably higher than that of the conventionally produced CP Ti, grade 4.

Spark Plasma Sintering

Spark plasma sintering operations were performed to consolidate virgin and cryomilled aluminum (Series 1100) and cryomilled WC-12Co. Cross-sectioned samples of the SPS processed powders show excellent bonding of adjacent grains in the sintered forms for both the virgin and cryomilled materials. The mechanical properties of the SPS materials are provided in Table 6.

The mechanical properties of the cryomilled aluminum and WC-12Co materials are improved over those of virgin and conventional materials in the consoli-

Table 5 — HIP Cryomilled CP Titanium

Element	Hardness (HVN _{1000 g})	Shear Strength (MPa)
Cryomilled CP Ti	393.2 Transverse 404.2 Longitudinal	648.1

dated forms. In the series 1100 aluminum, the strength and hardness of the cryomilled aluminum increased with the grain refinement and addition of nitrides. The hardness of the cryomilled Al was 3.0 times harder than the virgin Al, and the shear strength of the cryomilled Al was 2.1 times greater than the virgin aluminum.

The hardness of SPS cryomilled WC-12Co is 1.5 times greater than that of the

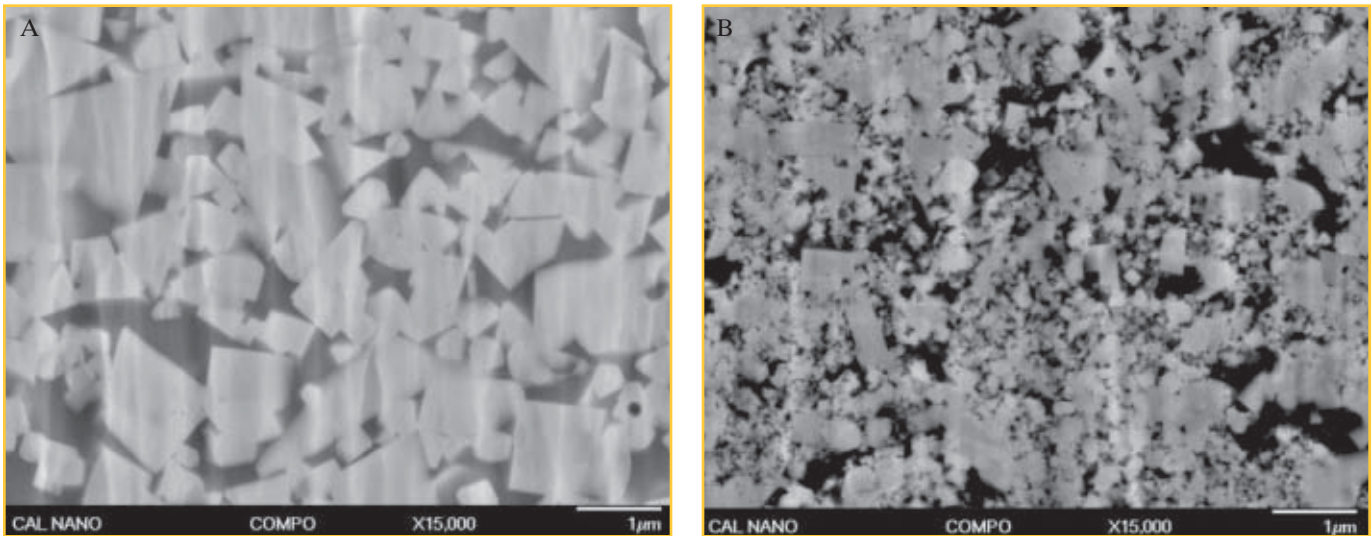


Fig. 9 — SEM images of cross-sectioned — A — Conventionally sintered ultrafine WC-12Co; B — SPS cryomilled WC-12Co powder after 16 h of milling.

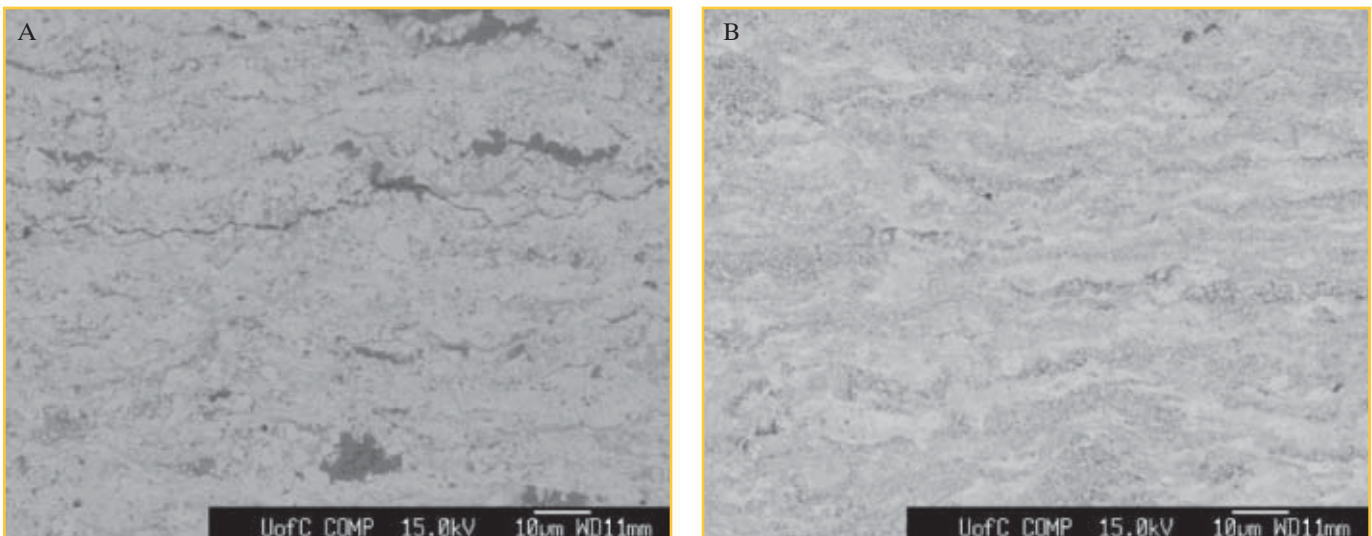


Fig. 10 — SEM images of cross-sectioned thermal sprayed samples of the following coatings: A — Microcrystalline WC-10Co-4Cr; B — near-nano WC-17Co.

Table 6 — Mechanical Properties of SPS Virgin and Cryomilled Aluminum, and SPS Cryomilled WC-12Co

Element	Hardness (HVN _{300 g} , HVN _{1000 g})	Ultimate Shear Strength
Virgin Al, Series 1100	29.8	129.0 MPa
Cryomilled Al, Series 1100	89.5	266.2 MPa
Conventional Ultrafine WC-12Co	1551.5	—
Cryomilled WC-12Co	2400.0	—

conventionally sintered, ultrafine WC-12Co material. Property improvements in the cryomilled materials are a result of the nano- and near-nano grains of WC in the matrix, as predicted by the Hall-Petch relationship. Figure 9 shows SEM images of cross-sectioned conventionally sintered ultrafine WC-12Co and spark plasma sin-

tered, cryomilled WC-12Co powder. The reduced size of the tungsten carbide in cryomilled powder is evident.

Thermal Spraying

In research conducted by Hyperion Technologies, microcrystalline WC-10Co-

4Cr and nano and near-nano WC-17Co powders were sprayed to evaluate coating properties as a result of nanocrystalline grains (Ref. 6). The microstructures of the HVOF sprayed coatings were examined using SEM, and the micrographs of the microcrystalline and nanocrystalline as-sprayed coatings are shown in Fig. 10A and B, respectively.

The nanocrystalline coatings produced using HVOF contained a finer dispersion of WC grains as compared with the conventional microcrystalline coating. The microstructure also showed that the microcrystalline coating contained a greater percentage of porosity than the nanocrystalline coating.

Sliding wear resistance of the coatings was evaluated using a reciprocal pin-on-plate wear tester, following ASTM Stan-

Table 7 — Microhardness and Wear Resistance of Thermal Sprayed HVOF Spray Microcrystalline WC-10Co-4Cr and Near-Nano WC-17Co

Material	HVOF WC-10Co-4Cr	WC-17Co
Hardness (HVN _{300 g})	1048	1440
Wear Rate (mm ³ /Nm)	0.009	0.0065

dard G133-05. A comparison of the wear test data and corresponding Vickers microhardness numbers (HV300) for the surfaces is given in Table 7.

It was observed that there was a 30% increase in sliding wear resistance and an average 25% increase in hardness in the near-nano WC-17Co coating when compared with the microcrystalline WC-10Co-4Cr coating. The increase in wear resistance of the nanostructured coating over the microcrystalline coating is primarily attributed to the significant increase in microhardness of the nanostructured coating.

Microhardness values of the HVOF WC-based coatings are considerably lower than those of the SPS samples. However, a considerable improvement is observed in both the HVOF coatings and SPS samples using nanocrystalline powders. Mechanical properties of thermal spray coatings have been related to those of bulk materials (Ref. 16), and a relationship may similarly exist for those consisting of nanocrystalline powders.

Conclusion

Bulk powder consolidation techniques (HIP, SPS) provide a useful baseline by which to evaluate the potential properties of near-nano and nanocrystalline powders for use in thermal spray. By understanding the material property improvements with these near-nano and nanocrystalline powders in bulk forms, we may better understand potential property improvements using these nanocrystalline powders for use in thermal spray.

The properties of HIP and SPS consolidated forms of near-nano and nanograined materials are stronger and harder than consolidated forms consisting of conventionally sized (micron-size) materials. The hardness of cryomilled (i.e., near-nano and nano-grained) Al was 3.0 times harder than that of the virgin (micron size) Al, and the shear strength of the cryomilled Al was 2.1 times greater than that of the virgin aluminum. The hardness of SPS cryomilled WC-12Co was 1.5 times greater than that of the conventionally sintered, ultrafine WC-12Co material. The material property improvements in near-nano and nano materials follow the concept established by the Hall-Petch relationship.

In thermal spraying of near-nano and nanocrystalline powders, the coating properties improved with a reduction in grain size. There was a 30% increase in sliding wear resistance and an average 25% increase in hardness in the near-nano WC-17Co coating when compared with the microcrystalline WC-10Co-4Cr coating.

The mechanical properties of thermal spray coatings have been reported to relate to those of bulk materials with conventional-sized powders, and a relationship may similarly exist for those consisting of nanocrystalline powders.

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ATTENTION: THERMAL SPRAY MARKETEERS

We would like to thank you for advertising in the third Thermal Spray profile of this type that the AWS *Welding Journal* has published. We will offer it again in the 2010.

If you would like more information on how to include your company in the next Thermal Spray profile in 2010, please contact us by email at salty@aws.org or garrigan@aws.org. You can also call us at 1-800-443-9353 ext. 243 or 220.

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CAN WE TALK?

The *Welding Journal* staff encourages an exchange of ideas with you, our readers. If you'd like to ask a question, share an idea or voice an opinion, you can call, write, e-mail or fax. Staff e-mail addresses are listed below, along with a guide to help you interact with the right person.

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CONFERENCES

2009 FABTECH International & AWS Welding Show Conference Schedule Chicago, Ill.

Weld Cracking: 'The Heat-Affected Zone' Conference November 16

One of production welding's greatest moments, the construction of the Liberty ships during World War II, was accompanied by a new problem. Weld cracking was observed on some of these ships, and the reason for the cracking was a mystery. The cause has since been determined, but as new metals and alloys have come into use the problem comes back in different forms to haunt the welding metallurgist. A crack costs money, takes time to repair, and interrupts production. So where does one go for help? The experts will be at Weld Cracking VII. You will obtain answers to your current problems and will be better prepared to solve cracking problems in the future. You can also learn about the latest equipment including induction heating, a wireless heat-treat system, and portable X-ray diffraction equipment. The use of fracture mechanics will be explored. Descriptions will be given on the heat-affected zone and on the many types of cracks that accompany welding. Base materials covered will include various steels, the stainless steels, aluminum, and titanium.

New Developments in Thermal Spray Coatings, Processes, and Applications Conference November 16

This one-day event organized by the American Welding Society and the International Thermal Spray Association will introduce the process and its uses to new potential users with sessions focusing on actual applications and new developments in thermal spray technology. It will include a half-day tutorial on thermal spray fundamentals titled "What Is Thermal Spray" sponsored by the International Thermal Spray Association.

Welding of Chrome-Moly Steels Conference November 17

The welding of chrome-moly steel goes back to the days when tubing was oxyacetylene welded to make up the fuselages of the early prealuminum airplanes. It all required outstanding precision on the part of the welder, and even though the methods have changed, the welding of 4130 steel still requires utmost precision. The welding of chrome-moly steels requires great skills on all parties involved, and not just the welding: heat treatment and non-destructive examination are essential to a successful weld. The 2½ Cr-1 Mo steels are popular materials for boilers and pressure vessels. More recently, the modified 9 Cr-1 Mo steel is widely specified in the electric utilities and is moving into the oil and gas industry. Conventional welding processes are all used effectively on 4130, 2½ Cr-1 Mo, and modified 9 Cr-1 Mo steels. Newer processes such as hybrid welding have also become popular.

For more information, please contact the AWS Conferences and Seminars Business Unit at (800) 443-9353, ext. 455. You can also visit the Conference Department at www.aws.org/conferences for upcoming conferences and registration information.

AWS/DVS Electron Beam Welding Conference November 16 and 17

This event will include a two-day technical program and a half-day tutorial. Join scientists, engineers, and technical personnel from around the globe who are involved in the research, development, and application of electron beam welding.

Welding the Corrosion-Resistant Alloys Conference November 18

Interest in welding corrosion-resistant alloys is extraordinarily high. The reasons include the entry of the duplex stainless steels and other high-performance grades. Another is the unstable prices in nickel, molybdenum, and titanium. When the price of nickel hit the roof, many fabricators switched from 316 to 201 stainless because of the latter grade's lower nickel content. Research is feverish throughout the world in the development of new and cheaper methods of producing titanium. Will a lower-cost titanium make the metal more popular? The overall activity is intense. Cladding and strip overlay processes have become more popular means of protecting parts exposed to heavy corrosion. Duplex stainless is now being welded for over-the-road tankage. Newer processes, like friction stir welding and thermal stir welding, will be discussed. Keep abreast of this exciting new world in welding where corrosion-resistant alloys have taken center stage.

CALL FOR PAPERS

LÖT 2010 9th Int'l Conf. on Brazing, High-Temperature Brazing, and Diffusion Bonding

June 15–17, 2010
Aachen, Germany

Deadline for submission of papers:
August 20, 2009.

Topics of interest include, but are not limited to, industrial applications; fundamentals; micro- and nanotechnologies; joining of glass, ceramics, and lightweight metals; modeling and simulation; quality assurance; inspection; and corrosion issues.

Sponsored by DVS and cosponsored by American Welding Society, ASM Int'l, Int'l Institute of Welding, and other societies.

For complete information and online registration, visit
www.dvs-ev.de/loet2010.



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Visit: www.aws.org/membership



American Welding Society

WELDING
WORKBOOK

Datasheet 307

Designing Welds to Avoid Fatigue Failure

When metals are subjected to cyclic tensile or alternating tensile-compressive stress, they may fail by fatigue. Performance of a weld under a cyclic load is an important consideration in structures and machinery. Specifications relating to fatigue in steel structures include those developed by the American Institute of Steel Construction, the American Association of State Highway and Transportation Officials, and the American Railway Engineering and Maintenance-of-Way Association. The latest edition of the appropriate standard should be consulted for specific information.

Although sound weld metal may have about the same fatigue strength as the base metal, any change in cross section at a weld lowers the fatigue strength of the member. In the case of a complete-joint-penetration groove weld, any reinforcement, undercut, incomplete joint penetration, or cracking acts as a notch or stress raiser. Each of these conditions is detrimental to fatigue life.

The very nature of a fillet weld transverse to the stress field

provides an abrupt change in section that may limit fatigue life. The metallurgical structure of the weld heat-affected zone can also act as a stress raiser.

When fatigue conditions exist, the anticipated cyclically applied loads, the number of cycles, and the desired service life must be given. The designer then selects the materials and details to accommodate the design conditions for each member and situation — Fig. 1. The designer then calculates the maximum stress in each member to ensure that it does not exceed the allowable stress for the static condition. If the calculated stresses under cyclic conditions exceed the allowable stress under static conditions, the member sections must be increased to bring the stresses within the allowable stress.

Partial-joint-penetration groove welds are not normally used in fatigue applications; however, their response to fatigue stresses is similar to that of fillet welds.

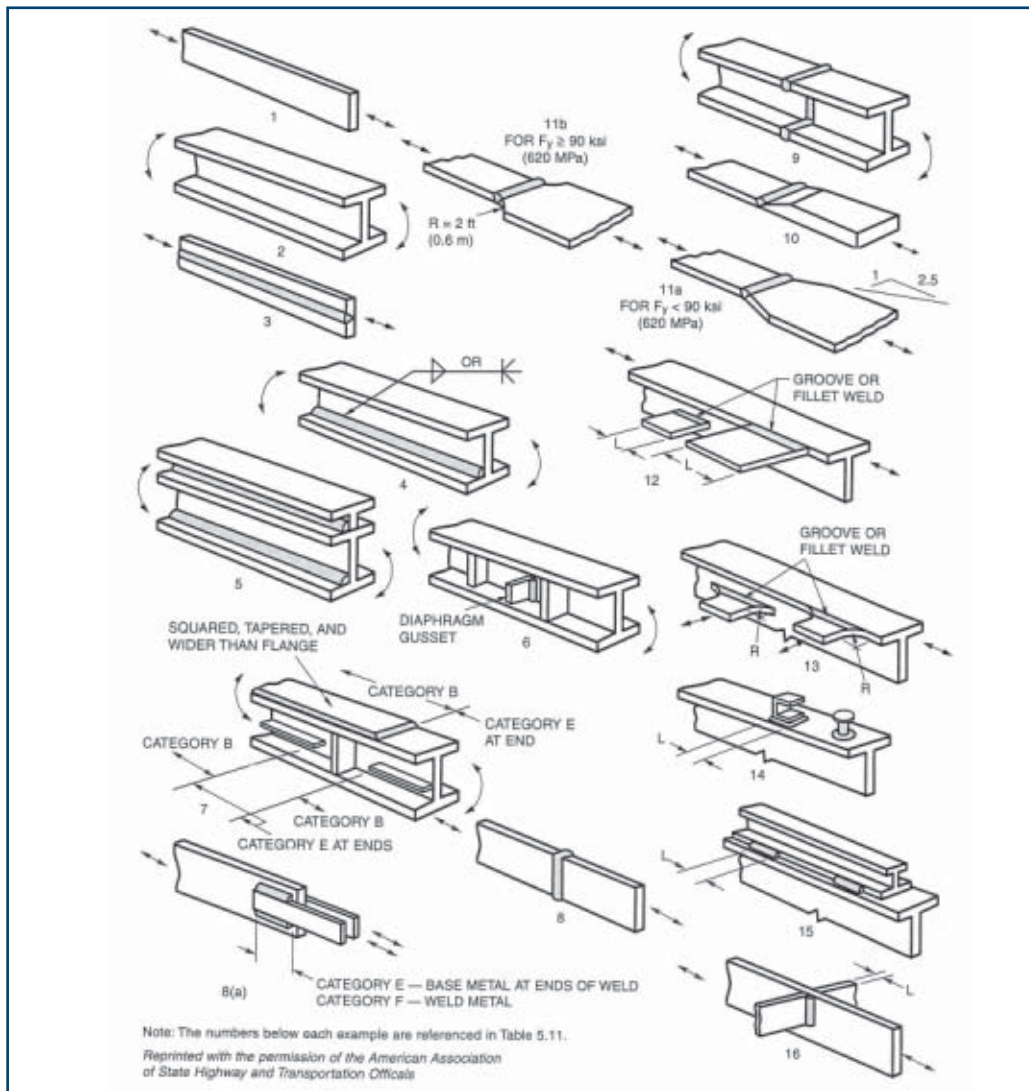


Fig. 1 — Examples of various fatigue categories. (Source: Adapted from AWS D1.1:2000, Structural Welding Code — Steel.)

Excerpted from the *Welding Handbook*, Vol. 1, ninth edition.

The AWS Foundation is pleased to announce additional scholarships for the 08-09 school year

National Scholarship Program

Congratulations to students at Southeastern Institute for Manufacturing and Technology
for the ESAB Welding & Cutting Scholarship

- ❖ James Battle
- ❖ Johntavis Hunter
- ❖ Daniel Sanders
- ❖ Wilbert Self
- ❖ Angela Thomas



Congratulations to **Spencer M. Harrell**,
the 2008-2009 recipient of the James A.
Turner, Jr. Memorial Scholarship

"I would like to thank the James A. Turner family
and the AWS Foundation for selecting me for
this generous award. By receiving this
scholarship, I will be able to continue my pursuit
of a career in the management field."

Northwestern State University
Business Administration – Management

Section Named Scholarship Program

Scholarships sponsored by AWS Section to
support students in their communities.

Congratulations to **Sean Pierce**,
the 2008-2009 recipient of the Donald and
Jean Cleveland – Willamette Valley Section
Named Scholarship.

"I am very honored and pleased to be chosen as
a recipient of the American Welding Society
scholarship program. I guarantee that this
scholarship will be put to great use and will help
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always be remembered."

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For specific information on the Scholarship Programs, please visit our website at
www.aws.org/foundation.

COMING EVENTS

NOTE: A DIAMOND (♦) DENOTES AN AWS-SPONSORED EVENT.

7th Int'l Expo on Electric Power Equipment and Technology and 6th Int'l Expo on Electrical Engineering, Electrical Equipment, and Contractors' Supplies. July 8–10. Shanghai Int'l Expo Center, Shanghai, PR, China. Visit www.2456.com/ep.

Int'l Metallographic Society Annual Convention. July 26–30, Richmond, Va. Sponsored by ASM Int'l. Held during Microscopy and Microanalysis. Visit <http://mm2009.microscopy>.

Titanium 2009 Conf. and Expo. Sept. 13–16, Hilton Waikoloa Village, Waikoloa, Hawaii. Sponsored by the Int'l Titanium Assn. Visit www.titanium.org.

Essen Welding Fair (Schweissen & Schneiden). Sept. 14–19, Essen, Germany. Visit www.messe-essen.de.

25th ASM Heat Treating Society Conf. and Expo. Sept. 14–17, Indiana Convention Center and RCA Dome, Indianapolis, Ind. Visit www.asminternational.org.

Asiamold — Guangzhou Int'l Trade Fair for Moldmaking and Tooling, Design and Application Development. Sept. 16–18, Poly World Trade Centre Expo, Guangzhou, China. Visit www.messefrankfurt.com.

♦ **GAWDA Annual Meeting.** Sept. 20–23, Grand Hyatt Hotel, San Antonio, Tex. Sponsored by Gases and Welding Distributors Assn. Visit www.gawda.org.

Numerical Analysis of Weldability, 9th Int'l Seminar. Sept. 28–30, Graz-Seggau, Austria. Sponsored by Graz University of Technology, Austria Institute for Materials Science and Welding, and IIW Commission IX working group Mathematical Modeling of Weld Phenomena. Visit <http://iws.tugraz.at>.

SOUTH-TEC. Oct. 6–8, Charlotte Convention Center, Charlotte, N.C. Contact Society of Mfg. Engineers, (800) 733-4763; or visit www.sme.org/southtec.

♦ **Welding of Corrosion-Resistant Alloys Conf.** Oct. 6, 7, New Orleans, La. Contact American Welding Society, (800/305) 443-9353, ext. 229; or visit www.aws.org.

Power-Gen Asia and Renewable Energy World Asia Conf. and Expo. Oct. 7–9, IMPACT Exhibition & Convention Centre, Bangkok, Thailand. Visit www.powergenasia.com.

The Aluminum Association Annual Meeting, "2010: Opportunities & Challenges." Oct. 19, 20, Hotel Palomar & Waterview Conf. Center, Arlington, Va. Visit www.aluminum.org.

SNAME 2009 Annual Meeting and Expo. Oct. 21–23, Providence, R.I. Contact Society of Naval Architects & Marine Engineers. Visit www.snameexpo.com.

MACHTECH 9th Int'l Expo for Machine Tools, Industrial Tools, Welding and Cutting Equipment. Oct. 22–25, Cairo Fair Ground, Cairo, Egypt. Visit www.ifg-eg.com.

96th ASM Annual Meeting at MS 2009. Oct. 25–29, Pittsburgh, Pa. Coorganized by ASM Int'l, ACerS, and AIST. Visit www.matscitech.org.

National Robot Safety Conf. XXI. Oct. 26–29, Hyatt Regency, Dearborn, Mich. Contact Robotic Industries Assn. at ria@informz.net or ria@robotics.org.

2009 Shanghai Int'l Science Journals Summit. Oct. 27, 28, Shanghai, P.R., China. Visit www.sjs-sh.org.cn.

ICALEO®, 28th Int'l Congress on Applications of Lasers & Electro-Optics. Nov. 2–5, Hilton in the Walt Disney World Resort®, Orlando, Fla. This conference is where researchers and end-users will meet to review state-of-the-art laser materials processing and project what lies in the future. Laser Institute of America's goal for ICALEO® is to bring both academic and industrial people together who may benefit from laser technology. E-mail Laser Institute of America at conferences@laserinstitute.org; or visit www.icaleo.org.

♦ **FABTECH International & AWS Welding Show** now including **METALFORM.** Nov. 15–18, McCormick Place, Chicago, Ill. This show is the largest event in North America dedicated to showcasing the full spectrum of metal forming, fabricating, tube and pipe, welding equipment, and technology. Contact American Welding Society, (800/305) 443-9353, ext. 455; or visit www.aws.org.

35th Int'l Symposium for Testing Failure Analysis (ISTFA). Nov. 15–19, San Jose, Calif. Visit www.asminternational.org.

♦ **Weld Cracking VII.** Nov. 16, Chicago, Ill. Held during the FABTECH International & AWS Welding Show. Contact American Welding Society, (800/305) 443-9353, ext. 455; or visit www.aws.org.

TECHNICAL TRAINING

The Hobart Institute of Welding Technology offers our comprehensive Technical Training courses throughout the year! Upcoming dates:

Prep for AWS Certified Welding Supervisor Exam
Aug 10-14 • Nov 30-Dec 4

Prep for AWS Welding Inspector/Educator Exam
Jul 13-24 • Aug 24-Sep 4 • Sep 28-Oct 9 • Nov 2-13

Visual Inspection
Nov 23-24

Welding for the Non Welder
Aug 17-20 • Oct 12-15

Arc Welding Inspection & Quality Control
Jul 27-31 • Oct 19-23

Weldability of Metals, Ferrous & Nonferrous
Jul 13-17 • Aug 10-14 • Sep 7-11 • Oct 5-9 • Nov 2-6

Liquid Penetrant & Magnetic Particle Inspection
Aug 3-7 • Oct 26-30



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or visit us at www.welding.org
for more information.

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Technology, Troy, OH
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For info go to www.aws.org/ad-index

◆ **Int'l Electron Beam Conf.** Nov. 16, 17, Chicago, Ill. Held during the FABTECH International & AWS Welding Show. Contact American Welding Society, (800/305) 443-9353, ext. 455; or visit www.aws.org.

◆ **Welding Chrome-Moly Steels Conf.** Nov. 17, Chicago, Ill. Held during the FABTECH International & AWS Welding Show. Contact American Welding Society, (800/305) 443-9353, ext. 455; or visit www.aws.org.

◆ **Welding Corrosion-Resistant Alloys Conf.** Nov. 18, Chicago, Ill. Held during the FABTECH International & AWS Welding Show. Contact American Welding Society, (800/305) 443-9353, ext. 455; or visit www.aws.org.

9th Int'l Welding Conf. and Expo. Dec. 1-3, World Trade Center, Yekaterinburg, Russian Federation. Visit www.uv2000.ru.

◆ **Power-Gen Int'l.** Dec. 8-10, Las Vegas, Nev. Contact American Welding Society, (800/305) 443-9353, ext. 455; or visit www.aws.org.

◆ **LÖT 2010, 9th Int'l Conf. on Brazing, High-Temperature Brazing, and Diffusion Bonding.** June 15-17, Aachen, Germany. Sponsored by DVS (German Welding Society), cosponsored by AWS, ASM Int'l, and other societies. Visit www.dvs-ev.de/loet2010.

21st World Energy Congress. Sept. 12-16, 2010, Palais des Congrès, Montreal, Que., Canada. Visit <http://montreal2010.ca>.

Educational Opportunities

Automotive Body in White Training for Skilled Trades and Engineers. Orion, Mich. A five-day course covers operations, troubleshooting, error recovery programs, and safety procedures for automotive lines and integrated cells. Contact Applied Mfg. Technologies, (248) 409-2000, www.appliedmfg.com.

Basics of Valves and Actuators Seminars and Expo. Oct. 29, Sheraton Houston Brookhollow Hotel, Houston, Tex. Sponsored by Valve Manufacturers Assn. Visit <http://vma.yourmembership.com/?valvebasics>.

Basic and Advanced Welding Courses. Cleveland, Ohio. Contact The Lincoln Electric Co. for schedules, www.lincolnelectric.com.

Boiler and Pressure Vessel Inspectors Training Courses and Seminars. Columbus, Ohio. Call (614) 888-8320; visit www.nationalboard.org.

CWI/CWE Course and Exam. Troy, Ohio. This is a ten-day program. Contact Hobart Institute of Welding Technology, (800) 332-9448, www.welding.org/technical/schedule2008.html.

CWI/CWE Prep Course and Exam and NDT Inspector Training Courses. An AWS Accredited Testing Facility. Courses held year-round in Allentown, Pa., and at customers' facilities. Contact: Welder Training & Testing Institute, (800) 223-9884, info@wtti.edu; visit www.wtti.edu.

CWI Preparatory and Visual Weld Inspection Courses. Classes presented in Pascagoula, Miss., Houston, Tex., and Houma and Sulphur, La. Contact: Real Educational Services, Inc., (800) 489-2890, info@reaeducational.com.

Environmental Online Webinars. Free, online, real-time seminars conducted by industry experts. For topics and schedule, visit www.augustmack.com/Web%20Seminars.htm.

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Gas Detection Made Easy Courses. Online and classroom courses for managing a gas monitoring program from gas detection to confined-space safety. Contact Industrial Scientific Corp., (800) 338-3287; www.indsci.com/serv_train.asp.

Hellier NDT Courses. Contact Hellier, 277 W. Main St., Ste. 2, Niantic, CT 06357; (860) 739-8950; FAX (860) 739-6732.

Inspection Courses on ultrasonic, eddy current, radiography, dye penetrant, magnetic particle, and visual at Levels 1-3. Meet SNT-TC-1A and NAS-410 requirements. Contact TEST NDT, Inc., (714) 255-1500, www.testndt.com.

Laser Safety Online Courses. Courses include Medical Laser Safety Officer, Laser Safety Training for Physicians, Industrial Laser Safety, and Laser Safety in Educational Institutions. Contact Laser Institute of America, (800) 345-3737, www.laserinstitute.org.

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AWS Certification Schedule

Certification Seminars, Code Clinics and Examinations

Application deadlines are six weeks before the scheduled seminar or exam. Late applications will be assessed a \$250 Fast Track fee.

Certified Welding Inspector (CWI)

LOCATION	SEMINAR DATES	EXAM DATE
Miami, FL	EXAM ONLY	Jul. 16
Fargo, ND	Jul. 12-17	Jul. 18
New Orleans, LA	Jul. 12-17	Jul. 18
Sacramento, CA	Jul. 12-17	Jul. 18
Phoenix, AZ	Jul. 19-24	Jul. 25
Orlando, FL	Jul. 19-24	Jul. 25
Milwaukee, WI	Jul. 19-24	Jul. 25
Cleveland, OH	Jul. 26-31	Aug. 1
Los Angeles, CA	Jul. 26-31	Aug. 1
Louisville, KY	Jul. 26-31	Aug. 1
Denver, CO	Aug. 2-7	Aug. 8
Philadelphia, PA	Aug. 2-7	Aug. 8
San Diego, CA	Aug. 9-14	Aug. 15
Miami, FL	Aug. 9-14	Aug. 15
Charlotte, NC	Aug. 16-21	Aug. 22
San Antonio, TX	Aug. 16-21	Aug. 22
Bakersfield, CA	Aug. 16-21	Aug. 22
Rochester, NY	EXAM ONLY	Aug. 22
Portland, ME	Aug. 23-28	Aug. 29
Salt Lake City, UT	Aug. 23-28	Aug. 29
Seattle, WA	Aug. 23-28	Aug. 29
Corpus Christi, TX	EXAM ONLY	Aug. 29
Pittsburgh, PA	Aug. 30-Sept. 4	Sept. 5
Houston, TX	Aug. 30-Sept. 4	Sept. 5
Minneapolis, MN	Aug. 30-Sept. 4	Sept. 5
St. Louis, MO	Sept. 20-25	Sept. 26
Miami, FL	Sept. 20-25	Sept. 26
New Orleans, LA	Sept. 20-25	Sept. 26
Anchorage, AK	EXAM ONLY	Sept. 26
Tulsa, OK	Oct. 4-9	Oct. 10
Long Beach, CA	Oct. 4-9	Oct. 10
Newark, NJ	Oct. 4-9	Oct. 10
Miami, FL	EXAM ONLY	Oct. 15
Portland, OR	Oct. 18-23	Oct. 24
Roanoke, VA	Oct. 18-23	Oct. 24
Cleveland, OH	Oct. 18-23	Oct. 24
Atlanta, GA	Nov. 1-6	Nov. 7
Dallas, TX	Nov. 1-6	Nov. 7
Sacramento, CA	Nov. 1-6	Nov. 7
Spokane, WA	Nov. 1-6	Nov. 7
Corpus Christi, TX	EXAM ONLY	Nov. 21
St. Louis, MO	EXAM ONLY	Dec. 5
Syracuse, NY	Dec. 6-11	Dec. 12
Reno, NV	Dec. 6-11	Dec. 12
Miami, FL	Dec. 6-11	Dec. 12

9-Year Recertification Seminar for CWI/SCWI

LOCATION	SEMINAR DATES	EXAM DATE
San Diego, CA	Jul. 13-18	NO EXAM
Orlando, FL	Aug. 24-29	NO EXAM
Dallas, TX	Oct. 5-10	NO EXAM
Miami, FL	Nov. 30-Dec. 5	NO EXAM

For current CWIs and SCWIs needing to meet education requirements without taking the exam. If needed, recertification exam can be taken at any site listed under Certified Welding Inspector.

For information on any of our seminars and certification programs, visit our website at www.aws.org/certification or contact AWS at (800) 443-9353, Ext. 273 for Certification and Ext. 455 for Seminars. Please **apply early** to save Fast Track fees. **This schedule is subject to change without notice.** Please verify the dates with the Certification Dept. and confirm your course status before making final travel plans.

Certified Welding Supervisor (CWS)

LOCATION	SEMINAR DATES	EXAM DATE
Minneapolis, MN	Jul. 20-24	Jul. 25
Philadelphia, PA	Aug. 31- Sep. 4	Sep. 5
Tulsa, OK	Oct. 5-9	Oct. 10
Long Beach, CA	Nov. 30-Dec. 4	Dec. 5

CWS exams are also given at all CWI exam sites.

Certified Radiographic Interpreter (CRI)

LOCATION	SEMINAR DATES	EXAM DATE
Houston, TX	Jul. 27-31	Aug. 1
Miami, FL	Oct. 19-23	Oct. 24

Radiographic Interpreter certification can be a stand-alone credential or can exempt you from your next 9-Year Recertification.

Certified Welding Sales Representative (CWSR)

LOCATION	SEMINAR DATES	EXAM DATE
Miami, FL	Oct. 21-23	Oct. 23
Chicago, IL	Nov. 16-18	Nov. 18

CWSR exams will also be given at certain CWI exam sites. Call for details.

Certified Welding Educator (CWE)

Seminar and exam are given at all sites listed under Certified Welding Inspector. Seminar attendees will not attend the Code Clinic portion of the seminar (usually first two days).

Senior Certified Welding Inspector (SCWI)

Exam can be taken at any site listed under Certified Welding Inspector. No preparatory seminar is offered.

Certified Robotic Arc Welding (CRAW)

LOCATION	WEEK OF:	CONTACT
Wolf Robotics, Ft. Collins, CO	Aug. 10	(970) 225-7736
Wolf Robotics, Ft. Collins, CO	Sept. 21	(970) 225-7736
Lincoln Electric, Cleveland, OH	Oct. 19	(216) 383-8542
Wolf Robotics, Ft. Collins, CO	Nov. 2	(970) 225-7736
Wolf Robotics, Ft. Collins, CO	Dec. 14	(970) 225-7736

Code Clinics & Individual Prep Courses

The following workshops are offered at all sites where the CWI seminar is offered (code books not included with individual prep courses): Welding Inspection Technology (prep course for CWI Exam Part A); Visual Inspection Workshop (prep course for CWI Exam Part B); and D1.1 and API-1104 Code Clinics (prep courses for CWI Exam Part C).

On-site Training and Examination

On-site training is available for larger groups or for programs customized to meet specific needs of a company. Call ext. 455 for more information.

International CWI Courses and Exams

AWS training and certification for CWI and other programs are offered in many countries. For international certification program schedules and contact information, please visit http://www.aws.org/certification/inter_contact.html



American Welding Society®

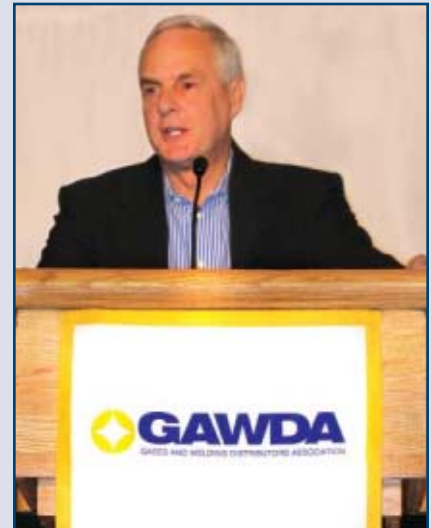
SOCIETY NEWS

BY HOWARD M. WOODWARD

Gases and Welding Distributors Association Conference Addresses Shortage of Welders

The Gases and Welding Distributors Association (GAWDA) Spring Management Conference, held April 21–24 in Asheville, N.C., featured talks by **Ray Shook**, AWS executive director, and **Monica Pfarr**, corporate director, Solutions Opportunity Squad (SOS).

Shook's talk was titled The Welding Industry Challenge: The Shortage of Skilled Welders. Shook addressed the steps AWS has taken to alleviate the problem. Part of his talk focused on the AWS Foundation's Solutions Opportunity Squad (SOS). Pfarr took the lectern at that point to detail the SOS activities and accomplishments to date. The subject matter was well received by the attendees, and the content will be the topic of an upcoming article in *CryoGas International* magazine (not affiliated with GAWDA).



Monica Pfarr and Ray Shook are shown at the Gases and Welding Distributors Association (GAWDA) Spring Management Conference in April.

D1 Structural Welding Committee Meets in Tucson



Shown at the March 20 meeting of the D1 Structural Welding Committee in Tucson, Ariz., are (front row, from left) Frank Armao, Lacy Collins, First Vice Chair Allen Sindel, Chairman Duane Miller, Second Vice Chair Todd Niemann, Eugene Bickford, Krishna Verma, and Joe Kiefer; (standing, from left) Michael Mayes, Jim Merrill, Nate Lindell, Don Rager, Dean Phillips, Stephen Luckowski, Ray Stieve, John Lawmon, Secretary Selvis Morales, Donald Scott, John Pearson, John Kenney, Tom Schlafly, Robert Lawrence, Bruce Butler, Robert Shaw, and Doug Luciani.

Tech Topics

Errata

AASHTO/AWS D1.5M/D1.5:2008 Bridge Welding Code

The following errata have been identified and incorporated into the current reprint of this document.

Page 89 — Clause 5.10.2 — Delete paragraph after the “Fillet Weld Properties” title so that no verbiage exists in the clause.

New Standard Project

C4.1-77 (R200X), *Criteria for Describing Oxygen-Cut Surfaces and Surface Roughness Guide for Oxygen Cutting*. This set consists of a plastic gauge with samples of oxygen-cut surfaces, and a document including descriptive terms and illustrations of surface cuts. Stakeholders: Oxyfuel gas cutters (operators) and inspectors as an aid to identify acceptance levels of oxygen-cut surfaces. C4.1 is also referenced in several AWS D1 structural welding documents.

Development work has begun on the above reaffirmed standard. Affected individuals are invited to contribute to the development of this standard. Contact: A. Alonso, ext. 299. Participation on all AWS technical committees is open to all persons.

Standards Approved by ANSI

C4.2/C4.2M:2009, *Recommended Practices for Safe Oxyfuel Gas Cutting Torch Operation*. Revision approved 5/4/09.

D1.8/D1.8M:2009, *Structural Welding Code — Seismic Supplement*. Revision approved 5/5/09.

D14.5/D14.5M:2009, *Specification for Welding of Presses and Press Components*. Revision approved 4/16/09.

D10.10/D10.10M:1999 (R2009), *Recommended Practices for Local Heating of Welds in Piping and Tubing*. Reaffirmed 5/5/09.

Standards for ANSI Public Review

A3.0M/A3.0:200X, *Standard Welding Terms and Definitions*. Revised — \$102. 6/22/09.

B5.15:200X, *Specification for the Qualification of Radiographic Interpreters*. Revised — \$25. 7/13/09.

D1.7/D1.7M:200X, *Guide for Strengthening and Repairing Existing Structures*. New — \$30. 6/29/09.

Official Interpretation

AWS D17.2/D17.2M:2007 Specification for Resistance Welding for Aerospace Applications

Subject: Spot Welds — Sheet and minimum strength requirements of Tables 1–4

Code Edition: D17.2/D17.2M:2007

Code Provision: Table 2 and Section 4.7.4

AWS Log: D17.2-07-I01

Inquiry: In both paragraphs 1(a) Minimum and 1(b) Average of 4.7.4.1 Spot Welds — Sheet, the strength shall equal or exceed what is specified in Tables 1–3. The current application we are looking at will use Table 2.

The material combination is as follows: The top sheet will be 0.031-in.-thick 301 ½-hard corrosion-resistant steel (CRES) with an ultimate strength of 150,000 to 185,000 psi. The bottom sheet will be 0.037-in.-thick 301 ¼-hard CRES having an ultimate strength of 90,000 to 149,999 psi. Given the material combination has both dissimilar thicknesses and material ultimate strengths, when referring to Table 2 to determine the weld strength, the left column of Table 2 is identified as (Nominal Thickness of

Thinner Sheet). In this application, the thinner sheet would be the 0.031-in. 301 ½-hard CRES requiring the weld strength to be 1045 Min. and 1280 Min. Avg. However, when looking at the 0.037-in. 301 ¼-hard CRES, it would require a weld strength of 920 Min. and 1140 Min. Avg.

When determining the correct weld strength from Table 2, our engineering group has determined the thinner material would not apply in this application, due to the thicker material being the weaker of the two material strength values, and also requiring a lower weld tensile strength. However, our quality group states the left column of Table 2 identifies the thinner material as the controlling factor in determining the correct weld strength requirement.

Response: D17.2/D17.2M:2007 Tables 1, 2, 3, and 4 do not account for all variations and conditions, such as this example. In this case, **4.1.3.2 Design Allowable Certification** applies.

AWS was approved as an accredited standards-preparing body by the American National Standards Institute (ANSI) in 1979. AWS rules, as approved by ANSI, require that all standards be open to public review for comment during the approval process. The above standards are open for review until the dates shown. Draft copies may be obtained from R. O'Neill, ext. 451, roneill@aws.org.

ISO Standards for Public Review

ISO/DIS 3580.2, *Welding consumables — Covered electrodes for manual metal arc welding of creep-resisting steels — Classification*

ISO/DIS 11745, *Brazing for aerospace applications — Qualification test of brazers and brazing operators — Brazing of metallic components*

ISO/DIS 17633, *Welding consumables — Tubular cored electrodes and rods for gas shielded and non-gas shielded metal arc welding of stainless and heat-resisting steels — Classification*

ISO/DIS 18274, *Welding consum-*

ables — Wire and strip electrodes, wires and rods for fusion welding of nickel and nickel alloys — Classification

Copies of these draft standards are available for review and comment through your national standards body, which in the United States is ANSI, 25 W. 43rd St., 4th Fl., New York, NY 10036; (212) 642-4900. Any comments regarding ISO documents should be sent to your national standards body. In the United States, if you wish to participate in the development of International Standards for welding, contact Andrew Davis, ext. 466, adavis@aws.org.

Technical Committee Meetings

July 16, 17, Committee on Personnel and Facilities Qualification. Pittsburgh, Pa. Contact: J. L. Gayler, ext. 472.

Aug. 19, 20, International Standards Activities Committee. Cleveland, Ohio. Contact: A. R. Davis, ext. 466.

Aug. 19, 20, Technical Activities Committee. Cleveland, Ohio. Contact: J. L. Gayler, ext. 472.

New AWS Supporters

Affiliate Companies

Ahlborn Structural Steel, Inc.
1230 Century Ct.
Santa Rosa, CA 95403

Alshahin Co. for Metal Industries Ltd.
Old Kharj Rd.
Second Industrial City, 11383
Saudi Arabia

Capitol Steel
1355 Saskatchewan Ave.
Winnipeg, MB R3E 3K4, Canada

Indian Trail Plumbing
4524 N. Lincoln Ave.
Chicago, IL 60625

Marse Welding Supplies Inc.
PO Box 323, 2700 Hessmer Ave.
Metairie, LA 70002

SABIC
PO Box 11425, Jubail Ind. City
Eastern Province 31961, Saudi Arabia

Select Fabrications Co.
325 N. Cota St.
Corona, CA 92880

Sense of Siam Int'l Trading Ltd.
36197 M5 Plutaluang
Sattahip Chonburi 20180, Thailand

United States Marine Safety Associates
5050 Industrial Rd.
Farmingdale, NJ 07727

Stainless Piping Systems Inc.
12 Steinway Blvd., Unit 6
Toronto, ON M9W 6N4, Canada

Supporting Companies

Fabricators Plus
3206 Hershey Ave.
Muscatine, IA 52761

NG Resources Corp.
5500 N. County Rd. 1150
Midland, TX 79705

Educational Institutions

Calhoon MEBA Engineering School
27050 St. Michaels Rd.
Easton, MD 21601

Instituto de Soldadura Metweld
Ave. Rodrigo Gomez, 345 Col. Central
Monterrey 64190, Mexico

Pitt Community College
1986 Pitt Tech Rd.
Winterville, NC 28590

Sias Kelsey Campus
1130 Idylwyld Dr. N.
Saskatoon, SK S7K 3R5, Canada

Membership Counts

Member Grades	As of 6/01/09
Sustaining.....	509
Supporting.....	311
Educational.....	494
Affiliate.....	482
Welding distributor.....	46
Total corporate members.....	1,842
Individual members.....	51,425
Student + transitional members.....	5,873
Total members.....	57,298

South Texas College
3700 W. Military Hwy.
McAllen, TX 78503

Universidad Politecnica de Cartagena
Biblioteca Campus Muralla del Mar
Antiguo Edificio Antigonez/
Plaza Hospital #1
Cartagena, Murcia 30282, Spain

White Cone High School
28 N. Hwy. 77 Mile Past 31
White Cone, AZ 86031

District 21 Director Awards Announced

The District Director Award provides a means for District Directors to recognize individuals who have contributed their time and effort to the affairs of their local Section and/or District.

Nanette Samanich, District 21 director, has nominated the following individuals for this award:

Joe Fitzpatrick, Arizona
Stan Luis, California Central Coast
Raymond L. Jablonski, Hawaii

James Hollenberg, Hawaii
Dave Ebenhoe, Kern
Ted Balestino, Kern
Richard Hutchison, Long Bch./Or. Cty.
Winford Sartin, Long Bch./Or. Cty.
Bette Lawson, L.A./Inland Empire
George Rolla, L.A./Inland Empire
Henry Jackson, L.A./Inland Empire
Richard "Sam" Samanich, Nevada
Evelyn Schneider, San Diego
Connie Compton, San Fernando Valley
Bert Callender, San Fernando Valley

Districts Council Charter Approvals

On May 17, 2009, after due consideration, Districts Council approved the charter of the AWS Rio Grande Valley Section, Dist. 18.

Also approved were the charters for the following AWS Student Chapters: North Montco Technical Career Center, Dist. 2; Black Hills, Dist. 16; Clark College, Dist. 19; Arizona Western College Institute of Welding Technology, Dist. 21; San Diego, Dist. 21; and the Wilmington Skills Center, Dist. 21.

Candidates Sought for Prof. Masubuchi Award

November 2 is the deadline for submitting nominations for the 2010 Prof. Koichi Masubuchi Award, sponsored by the Dept. of Ocean Engineering at Massachusetts Institute of Technology. This award includes an honorarium of \$5000. It is presented each year to one person who has made significant contributions to the advancement of materials joining through

research and development.

The candidate must be 40 years old or younger, may live anywhere in the world, and need not be an AWS member. The nomination package should be prepared by someone familiar with the research background of the candidate. It should include the candidate's résumé listing background, experience, publications, honors, and awards, plus at

least three letters of recommendation from fellow researchers.

This award was established to recognize Prof. Koichi Masubuchi for his numerous contributions to the advancement of the science and technology of welding, especially in the fields of fabricating marine and outer space structures. E-mail your nominations to Prof. John DuPont at jnd1@lehigh.edu.

Member-Get-A-Member Campaign

Listed below are the people participating in the 2008–2009 AWS Member-Get-A-Member Campaign. For campaign rules and a prize list, see page 81 in this *Welding Journal*, and for complete campaign rules visit www.aws.org/mgm. The standings are as of May 19, 2009. If you have any questions regarding your member proposer points, call the AWS Membership Dept. (800/305) 443-9353, ext. 480.

Winner's Circle

Sponsored 20+ new members.

The superscript indicates the number of times the member has achieved Winner's Circle status since June 1, 1999.

J. Compton, San Fernando Valley⁷
E. Ezell, Mobile⁶
J. Merzthal, Peru²
G. Taylor, Pascagoula²
L. Taylor, Pascagoula²
B. Mikeska, Houston¹
W. Shreve, Fox Valley¹
M. Karagoulis, Detroit¹
S. McGill, NE Tennessee¹
T. Weaver, Johnstown/Altoona¹
G. Woomer, Johnstown/Altoona¹
R. Wray, Nebraska¹
M. Haggard, Inland Empire¹

President's Guild

Sponsored 20+ new members.

S. Esders, Detroit — 22

President's Roundtable

Sponsored 9–19 new members.

E. Ezell, Mobile — 19
P. Betts, Mobile — 12
R. Biggs, Nebraska — 9
J. Compton, San Fernando Valley — 9
S. Keskar, India — 9

President's Club

Sponsored 3–8 new members.

L. Contreras, South Florida — 8
R. Ellenbecker, Fox Valley — 8
P. Shahoveisi, International — 7
C. Daon, Israel — 6
D. Marquard, Cleveland — 6
R. Robles, Corpus Christi — 6
D. Wright, Kansas City — 6
W. Rice, Tri-State — 5
R. Shepherd, Fox Valley — 5
V. Craven, Pascagoula — 4
M. Hackl, Cuautitlan Izcalli — 4
D. Herr, York-Central Pa. — 4
G. Koza, Houston — 4
R. Newman, Maine — 4
B. Vernyi, Cleveland — 4
C. Becker, Northwest — 3
B. Franklin, Mobile — 3
R. Johnson, Detroit — 3
W. Komlos, Utah — 3
L. Moss, Sangamon Valley — 3
P. Newhouse, British Columbia — 3
M. Rahn, Iowa — 3
D. Roland, Upper Peninsula — 3
M. Wheat, Western Carolina — 3

President's Honor Roll

Sponsored 2 new members.

C. Alfaro, San Diego
T. Baldwin, Arrowhead
M. Boggs, Stark Central
M. Boyer, Detroit
R. Boyer, Nevada
K. Bristow, East Texas
K. Campbell, L.A./Inland Empire
J. Contreras, International
M. Cyphyert, Northwestern Pa.
D. De Almeida, Int'l
B. Donaldson, British Columbia
E. Dupree, Tidewater
T. Ferri, Boston
N. Goel, New York
F. Hendrix, New Jersey
J. Hilfiker, Kansas City
E. Hinojosa, L.A./Inland Empire
J. Hope, Puget Sound
T. Johnson, Pittsburgh
G. Lawrence, N. Central Florida
E. Levert, North Texas
J. Livesay, Nashville
J. Padilla, Cuautitlan Izcalli
S. Luke, Acadiana
M. Medrano, San Diego
T. Moffitt, Tulsa
J. Nash, Atlanta
R. Pitt, Tidewater
J. Polson, L.A./Inland Empire
J. Rule, Cleveland
W. Scott, Willamette Valley
J. Sisson, Niagara Frontier
K. Smith, North Texas
R. Somers, Northern New York
M. Spangler, J.A.K.
A. Stute, Madison-Beloit
J. Svatos, Siouxland
D. Thomason, Chicago
M. Torres, Pascagoula
B. Whatley, Albuquerque
R. Young, Iowa
M. Yung, Portland
D. Zabel, SE Nebraska
P. Zammit, Spokane

5+ Student Member Sponsors

J. Leen, Chicago — 136
D. Berger, New Orleans — 110
S. Esders, Detroit — 102
J. Kacir, Detroit — 86
B. Benyon, Pittsburgh — 46
D. Pickering, Central Arkansas — 40
A. Baughman, Stark Central — 36
M. Boggs, Stark Central — 36
R. Jones, Puget Sound — 36
A. Rowe, Philadelphia — 36
A. Zinn, Eastern Iowa — 34
T. Moore, New Orleans — 32
D. Saunders, Lakeshore — 31
E. Hinojosa, L.A./Inland Empire — 30
R. Hutchinson, Long Bch./Or. Cty. — 30
J. Carney, Western Michigan — 27
J. Roberts, Sacramento — 27
J. Harris, Pascagoula — 26
H. Hughes, Mahoning Valley — 26
E. Norman, Ozark — 26
S. Siviski, Maine — 26
T. Geisler, Pittsburgh — 24

J. Kline, Northern New York — 24
G. Moore, L.A./Inland Empire — 24
D. Newman, Ozark — 24
R. Newman, Maine — 24
R. Young, Iowa — 24
R. Cook, Utah — 23
D. Howard, Johnstown-Altoona — 23
J. Rule, Cleveland — 23
B. Suckow, Northern Plains — 23
L. Clark, Milwaukee — 22
D. Schnalzer, Lehigh Valley — 22
D. Zabel, SE Nebraska — 22
R. Munns, Utah — 21
A. Duron, New Orleans — 19
J. Fox, NW Ohio — 19
D. Ketler, Willamette Valley — 19
T. Strickland, Arizona — 19
D. Vranich, N. Florida — 19
J. Ciaramitaro, N. Central Florida — 18
R. Schmidt, Philadelphia — 18
J. Boyer, Lancaster — 17
R. Boyer, Nevada — 17
C. Donnell, NW Ohio — 16
B. Hallila, New Orleans — 16
M. Arand, Louisville — 14
W. Galvery Jr., Long Bch./Or. Cty. — 14
D. Kowalski, Pittsburgh — 14
G. Smith, Lehigh Valley — 14
A. Mattox, Lexington — 13
M. Piper, San Fernando Valley — 13
R. Rummel, Central Texas — 13
A. Stute, Madison-Beloit — 13
D. Taylor, Kern — 13
J. Daugherty, Louisville — 12
R. Ledford Jr., Birmingham — 12
J. Marshall, Siouxland — 12
G. Putnam, Green & White Mts. — 12
R. Evans, Siouxland — 11
J. Theberge, Boston — 11
A. Badeaux, Washington, D.C. — 10
C. Kipp, Lehigh Valley — 10
C. Abram, Columbus — 9
K. Caliva, New Orleans — 9
S. Colton, San Diego — 9
R. Norris, Maine — 9
V. Facchiano, Lehigh Valley — 9
D. Kearns, Northern Michigan — 8
M. Rabo, Sacramento — 8
G. Saari, Inland Empire — 8
N. Carlson, Idaho/Montana — 7
L. Caughron, Kansas City — 7
J. Fitzpatrick, Arizona — 7
J. Geesey, Pittsburgh — 7
T. Hopper, Mobile — 7
S. MacKenzie, Northern Michigan — 7
D. Roskiewich, Philadelphia — 7
I. Garza, Corpus Christi — 6
M. Hayes, Puget Sound — 6
J. Reed, Ozark — 6
G. Rolla, L.A./Inland Empire — 6
C. Schiner, Wyoming — 6
G. Baldree, Rio Grande Valley — 5
C. Hobson, Olympic Section — 5
T. Hopper, Mobile — 5
J. Livesay, Nashville — 5
R. Olesky, Pittsburgh — 5
S. Robeson, Cumberland Valley — 5
R. Roehl, Nashville — 5
R. Sand, Northern Plains — 5
T. Shirk, Tidewater — 5

SECTION NEWS



Shown at the Maine Section meeting are (from left) Greg Bushey, Mark Legel, Kevin Connelly, District 1 Director Russ Norris, Mike Gendron, Dick Gregoire, Tom Cormier, Fran Piccirillo, and Chair Scott Lee.



Dick Gregoire (left) presents Scott Lee a plaque for serving as Maine Section chair.

District 1

Russ Norris, director
(207) 604-9262
russ.norris@airgas.com

BOSTON

MAY 5

Activity: The Section held a planning meeting at Artisan Industries in Waltham, Mass. Chairman **Jim Shore** conducted the program. The Section received a proclamation from the office of **Deval Patrick**, governor of the Commonwealth of Massachusetts, proclaiming April as Welding Products Month in the state. **Russ Norris**, District 1 director, attended the meeting.

MAY 12

Activity: The Boston Section members took a tour of Capone Iron Corp. in Rowley, Mass. President **Steve Capone** and **John Streefkerk**, QA manager, conducted the program.

MAINE

APRIL 20

Activity: The Section's executive committee met to discuss year-end business and



Shown at the Boston Section May 5 meeting are (from left) Carl Richardson, Laurie Jones, Dave Paquin, District 1 Director Russ Norris, and Bob Lavoie.



Shown at the Boston Section May 12 program are (from left) Vice Chair Tom Ferri, Steve Capone, and John Streefkerk.

nominate incoming officers. Secretary **Dick Gregoire** presented **Scott Lee** with an appreciation plaque for his services as chairman. Also participating were Vice Chair **Tom Cormier**, Treasurer **Greg**

Bushey, **Mark Legel**, **Kevin Connelly**, **Mike Gendron**, **Fran Piccirillo**, and **Russ Norris**, District 1 director. The meeting was held at Verrillo's Restaurant in Portland, Maine.



Shown during the May Long Island Section tour are (from left) Ken Messemer, Harland Thompson, Tom Gartland, Ray O'Leary, Ron Pandolfi, Brian Cassady, Chair Anthony Zampelli, Tom Mazarella, and Cory Drogler.



New Jersey Section members are shown at the April meeting.



Shown at the Long Island Section program are (from left) Tom Gartland, Matt Graciolett, Brian Cassady, Chair John Broderick, presenter Paul Iannotta, Alex Duschere, and Vice Chair Harland Thompson.



Shown at the New Jersey Section program are (from left) Chair Seann T. Bradley, welding instructor David Griep, and speaker Wyatt Mann.

District 2

Kenneth R. Stockton, director
(908) 412-7099
kenneth.stockton@pseg.com

LONG ISLAND

APRIL 23

Activity: The Section members toured the welding shop at Barry Career and Technical Education Center in Westbury, N.Y., to review its two-year curriculum and make constructive criticisms to improve the program. Welding instructor **Paul Iannotta** and **Lauri Harris**, vice principal, conducted the tour.

MAY 14

Activity: The Long Island Section members toured the Ram Tech Mechanical Contracting facilities in Maspeth, N.Y. **Anthony Zampelli**, owner, demonstrated a wet tap process to add an auxiliary line to a pressurized pipe while in service.

NEW JERSEY

APRIL 21

Speaker: **Wyatt Mann**, sales engineer

Affiliation: The Lincoln Electric Co.

Topic: Fundamentals of flux cored arc welding

Activity: The meeting was held at Passaic County Technical Institute in Wayne, N.J.



Shown at the April Lehigh Valley program are (standing, from left) AWS President Vic Matthews, Tyler Fuller, John Woodling, Victoria Rundle, Scott Beers, John Keck, Devin Gibson, and District 3 Director Mike Wiswesser; (front, from left) Jake Amelio, Nick Sennetti, Steve Miller, Chris Tallamy, and Gage Rizzon.



Shown at the Lehigh Valley March program are (seated, from left) Victoria Rundle, Nick Sennetti, Steve Miller, and John Keck; (standing, from left) Greg Smith, Jake Amelio, Jesse Thomas, Vince Facchiano, Scott Beers, Tyler Fuller, John Woodling, Dave Marks, Devin Gibson, Gage Rizzon, Rich Lightcap, Chris Tallamy, and Jeff Swoyer.

PHILADELPHIA

APRIL 22

Activity: The Section hosted its students' night program at Divers Academy International in Erial, N.J. Director **Tamara Brown** discussed the various career opportunities in commercial diving and conducted a tour of the facility.

District 3

Michael Wiswesser, director
(610) 820-9551

mike@welderinstitute.com

LEHIGH VALLEY

MARCH 25

Activity: The Section hosted its 39th annual student welding competition at Monroe Career and Technical Institute in Bartonsville, Pa. Six area schools sent two students each to compete. The participants included **Victoria Rundle, Nick Sennetti, Steve Miller, John Keck, Greg Smith, Jake Amelio, Jesse Thomas, Vince Facchiano, Scott Beers, Tyler Fuller, John Woodling, Dave Marks, Devin Gibson, Gage Rizzon, Rich Lightcap, Chris Tallamy, and Jeff Swoyer.**



Shown at the Lehigh Valley Section program are (from left) Dave Schnalzer, AWS President Victor Matthews, Dave Marks, John Keck, Joseph Kasztejna, and Colin Phelps.

APRIL 7

Speaker: **Victor Matthews**, AWS president

Affiliation: The Lincoln Electric Co.

Topic: Careers in welding

Activity: The Lehigh Valley Section held its 39th annual awards-presentation banquet at The Meadows in Hellertown, Pa. **Colin Phelps** was the competition chairman. Celebrated were the winners of the recent welding competition, including **John Keck, Nick Sennetti, and Jake Amelio**, first-, second-, and third-place winners, respectively. Attending the program



Philadelphia Section Chair Gary Atherton is shown with presenter Tamara Brown.



Central Piedmont C.C. Student Chapter members are (top row, from left) Matthew Manning, Don Morris, Josh Bare, Matt Harper, Seth Jones, and Wesley Lambert; (front, from left) James Miller, Coleman Dyer, Trevor Bays, Kenly Ipock, Scott Mundorf, and Teddy Clayton.



Shown at the Central Piedmont C.C. Student Chapter are (top, from left) Coleman Dyer, Greg Bellamy, and Steve Gore; (front, from left) Byron Churchill and Ray Sosko.



Chef Justin Potteiger and his culinary students prepared dinner for the Reading Section members and guests.

were District 3 Director **Mike Wiswesser** and Lehigh Career and Technical Institute Administrator **Joseph Kasztejna** and instructors **Dave Schnalzer** and **Dave Marks**.

READING

APRIL 16

Speaker: **Michael Wiswesser**, District 3 director

Affiliation: Welder Training & Testing Institute, vice president
Topic: Opportunities for welders and the value of AWS membership
Activity: **Joe Young** received a certificate of appreciation for serving as Section chairman for two terms. The results of the Section-sponsored welding contest were announced by **Francis Butkus**, contest chair. Section Technical Representative and Librarian **John Stasik** explained how



John Stasik explained how the Reading Section technical library operates.



Joe Young (left), Reading Section chairman, is shown with Mike Wiswesser, District 3 director.

the Section library works, its location, and how to access the publications. The meeting was held at Reading-Muhlenberg Career & Technology Center in Reading, Pa. Chef **Justin Potteiger** and his culinary students prepared the dinner for the 44 attendees.

District 4

Roy C. Lanier, director
(252) 321-4285
rlanier@email.pittcc.edu



The Atlanta Section's member-recruiting event attracted a large and enthusiastic crowd.



Florida West Coast Section board members pose with District 5 Director Steve Mattson (far right).

Central Piedmont C.C. Student Chapter

MAY 1

Activity: Central Piedmont Community College, Harper Campus, Charlotte, N.C., hosted the ninth annual welding competition and the first annual blacksmithing competition for six colleges in the Carolinas and Virginia. Presenters included **Tyler Ratchford** of Liburdi Diametrics; **Jose Chavez**, Nature Center manager with the County Parks and Recreation Department; **Rand Ernst** of the NDE department at the college; and District 4 Director **Roy Lanier**.



The Atlanta Section officers pose for a group shot. Shown are (from left) Rene Engeron, David Ennis, Carl Matricardi, Chair Robbie Zappa, Tom Rieger, and Greg Engeron.

District 5

Steve Mattson, director
(904) 260-6040
steve.mattson@yahoo.com

ATLANTA

APRIL 16

Activity: The Section hosted an executive committee meeting to elect new officers combined with a member-recruiting event. Special guests included employees of Emergency Machining Services (EMS) Bearings and Power Group LLC. Incoming officers include Chair **Robbie Zappa**, Vice Chair **Carl Matricardi**, Secretary

Rene Engeron, Treasurer **Greg Engeron**, and **David Ennis**, education committee chair. The event was sponsored by EMS in Clarkston, Ga.

FLORIDA WEST COAST

MAY 2

Activity: The Section hosted its annual Shrimp-A-Roo dinner and dancing event for about 100 members and guests. District 5 Director **Steve Mattson** presented **Albert Sedory** an appreciation plaque for serving as chairman. **Robert Brewington** of Mactec Engineering was introduced as the Section's incoming chairman.



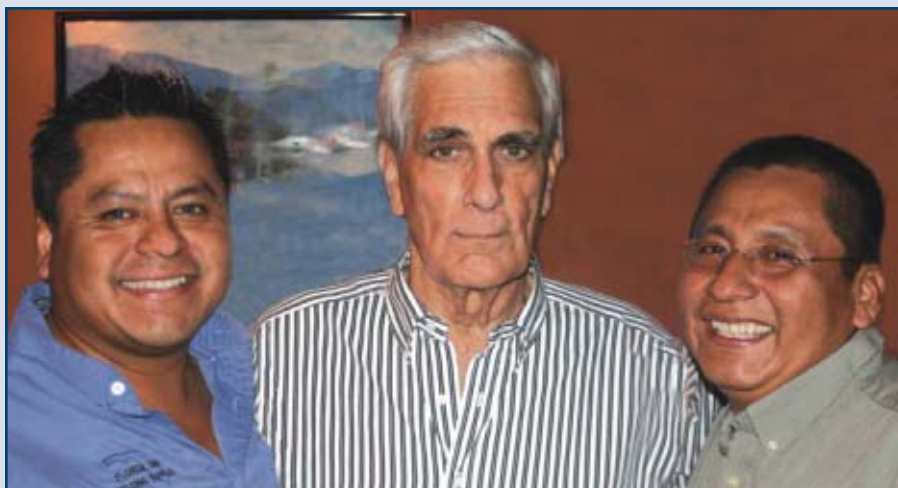
Robert Brewington (right), incoming Florida West Coast Section chair, is shown with Chair Al Sedory.



Al Sedory (left) is shown with Steve Mattson, District 5 director, at the Florida West Coast Section program.



Kevin Gay (left) and Paul French spoke at the North Central Florida Section's May program.



John F. Van Pelt (center) celebrates his retirement with South Florida Section Chair Gilly Burrior (left) and brother Otto.



Shown at the West Palm Beach Section program are speaker Jim Hurley (right) and Chairman Frank Rose.



Gary Parker discussed grinding safety at the West Palm Beach Section program in April.

NORTH CENTRAL FLORIDA

OCTOBER 14, 2008

Activity: The Section members toured the Commercial Metals Co. Joist and Deck facility in Starke, Fla. **DeWayne Tyson**, shop superintendent, presented a history of the company then led the tour. Chairman **Mark Geiger** discussed a partnership between education and industry, and District 5 Director **Steve Mattson** spoke on the current shortage of welders and job opportunities. Students from Bradford Union Vo Tech attended the program.

FEBRUARY 17

Speaker: **Bobby Plummer**, area technical representative
Affiliation: Smith Torches, Watertown, S.Dak.

Topic: Torch and gas cylinder safety

Activity: Following the talk and a video, the North Central Florida Section members studied demonstrations of the proper use of welding torches. The meeting was held at Mid-Florida Technical Institute in Orlando, Fla. The meeting was attended by 47 members and students.

MAY 12

Activity: The North Central Florida Section held a students' night program at Community Technical & Adult Education in Ocala, Fla. **Kevin Gay**, workforce program specialist at Progress Energy, discussed the workforce skills required in the expansion of the nuclear power industry. **Paul French**, Milwright Council representative at the United Brotherhood of Carpenters and Joiners of America, discussed the entry-level qualifications required for workers to enter these industries. About 60 people participated including many students from Bradford Union Area Community Technical College, Santa Fe College, Central Florida Community College, and Mid-Florida Technical Institute. The Section awarded ten AWS Student Memberships as prizes.

SOUTH FLORIDA

MAY

Activity: Chairman **Gilly Burrior** and his brother Otto celebrated with **John F. Van Pelt** on his retirement as a Miller Electric representative. The event was hosted and arranged by the Burrior family-owned Florida Gas Welding Supply at a local Hollywood, Fla., restaurant along with friends, family and Miller representatives.

WEST PALM BEACH

FEBRUARY 25

Speaker: **Jim Hurley**, regional sales manager

Affiliation: Trumpf Inc.

Topic: Update on laser material processing

Activity: The program was held in Lake Worth, Fla.

APRIL 22

Speaker: **Gary Parker**

Affiliation: Metabo Corp.

Topic: Grinding safety and proper use of power tools

Activity: This West Palm Beach Section program was held in Lake Worth, Fla.

District 6

Kenneth Phy, director

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kenneth.phy@gmail.com

NIAGARA FRONTIER

APRIL 30

Speaker: **Ron Stahura**

Affiliation: ESAB Group

Topic: Comparing the advantages and disadvantages of using plasma arc cutting vs. oxyfuel

Activity: The program was held in Depew, N.Y., for 25 attendees.

NORTHERN NEW YORK

MAY 5

Activity: The Section members toured Dynamic Systems Inc. in Poestenkill, N.Y. The company manufactures Gleeble® systems in different sizes and configurations featuring high-speed heating, servo hydraulics, computer control, and data acquisition for dynamic thermomechanical testing of materials. **Dave Ferguson** conducted the tour.

District 7

Don Howard, director
(814) 269-2895
howard@ctc.com

COLUMBUS

APRIL 16

Speaker: **Shahrukh Irani**, assoc. professor

Affiliation: The Ohio State University, School of Industrial Engineering

Topic: How facility layout and design inspires a new approach to lean in nonassembly facilities

Activity: The Section joined members of local chapters of seven other technical societies for this program, held at Arlington Banquets in Columbus, Ohio.

DAYTON

MAY 12

Speaker: **Michael Klos**, general manager, Midwest operations

Affiliation: IPG Photonics

Topic: Material processing with fiber lasers

Activity: The program was held at Amber Rose Restaurant in Dayton, Ohio.

PITTSBURGH

APRIL 14

Speaker: **Gary Lewis**, director of business development

Affiliation: Superheat FGH

Topic: Wireless heat treating technology for off-site monitoring

Activity: **Daniel Byard**, from Jefferson County Career Center, was honored for taking first place in the 20th annual weld off and **Steven Scotty** of West Hills took second place. Byard received a pipe welding course at the Lincoln Electric school.

District 8

Joe Livesay, director
(931) 484-7502, ext. 143
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HOLSTON VALLEY

APRIL 14

Activity: The Section hosted its annual students' night and welding competition



Shown at the Niagara Frontier Section program are (from left) Paul Swatland, Fred Schmidt, Bob Kovalchuk, speaker Ron Stahura, and Bob Cameron.



Shown at the Holston Valley Section program are (from left) Roger Painter, speaker Jerry Sullivan, Doc Bishop, Mike Brown, Chairman Bob Thomas, and Richard Newman.



Speaker Michael Klos (left) is shown with Steve Whitney, Dayton Section chairman.



Pittsburgh Section Chair Dave Daugherty (left) congratulates Daniel Byard, first-place weld-off winner.



Shown at the Holston Valley program are (from left) Michael Franklin, Mike Brown, and Dustin Smith.



Speaker Gary Lewis (left) is shown with Pittsburgh Section Chair Dave Daugherty.



Shown during the Mobile Section April 16 tour are (from left) Andy Hicks, Chairman Joshua Sanders, and Uwe Arenz.



Mobile Section scholarship awardees included (from left) Daniel Haan, Morgan Murphy, Scotty Jones, Alec Estes, Alvin Brock, and Tallya Poole.



Dennis W. Wyatt received the Student Chapter Member Award at the Birmingham Section program in April.



Joshua Sanders (right) receives a chairman appreciation plaque from Randy Henderson at the Mobile Section May 14 meeting.



Shown at the New Orleans Section program are (from left) DJ Berger, Todd Taranto, Vic Schmitt, and Chair Matthew Howerton.



Speaker Tom Cooper chats with Matthew Howerton, New Orleans Section chair.

for area high school and adult education students. **Jerry Sullivan**, a welding instructor at Tennessee Technology Center, Surgoinsville, Tenn., conducted the contest. **Mike Brown** of Amen Chassis was a special guest who helped judge the students' work. Students **Michael Franklin** and **Dustin Smith** took top honors. Elections of officers was held, and plans were made for meetings and tours.

District 9

George D. Fairbanks Jr., director
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fits@bellsouth.net

BIRMINGHAM

APRIL 20

Activity: **Dennis W. Wyatt**, a member of the Lawson State Community College Student Chapter was presented the Student Chapter Member Award. Wyatt was nominated for the award by **Roy Ledford Jr.**, Chapter advisor. Wyatt has maintained nearly a 4.0 GPA, and has been recognized on both the Lawson State Dean's List and the President's List. He served as Chapter chairman, was the recipient of the school's 2009 Outstanding Student Award in Welding Technology, and was also invited to attend the 14th annual workshop hosted by the AWS Baton Rouge Section.

MOBILE

APRIL 16

Activity: The Section members toured Berg Steel Pipe Corp. in Mobile, Ala. Conducting the program were **Andy Hicks** and **Uwe Arenz**.

MAY 14

Activity: The Mobile Section held its election of officers and awards-presentation program at Saucy Q BBQ in Mobile, Ala., for 33 attendees. **Joshua Sanders** received an appreciation award for serving as chairman. Scholarships were presented to **Daniel Haan**, **Morgan Murphy**, **Scotty Jones**, **Alec Estes**, **Alvin Brock**, and **Tallya Poole**.



District 10 conference attendees are shown during their tour of Joy Mining Machinery.



Richard Harris (left), District 10 director, is shown with Craig Newell at the joint meeting of the Drake Well and Northwestern Pennsylvania Sections.



Shown at the New Orleans Section meeting are (from left) Chair Matthew Howerton, awardee Alex Wise, Paul C. Hebert, and DJ Berger, incoming chair.

NEW ORLEANS

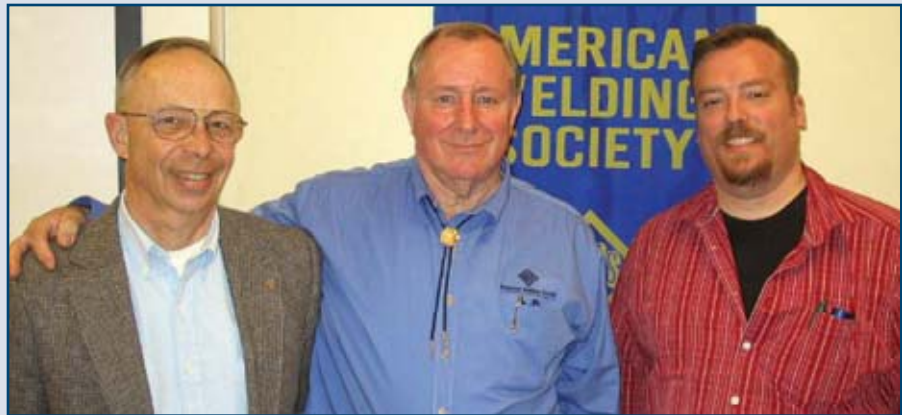
MAY 19

Speaker: **Tom Cooper**, manager

Affiliation: Gas Innovations

Topic: Fuel gases in cutting processes

Activity: Wesco Gas & Welding Supply sponsored this program in New Orleans, La. Chair **Matthew Howerton** and incoming Chair **DJ Berger** presented Wesco representatives **Todd Taranto** and **Vic Schmitt** a sponsor-appreciation plaque. Student **Alex Wise** of Local 60 received an award for his perfect attendance at the Section's meetings.



Shown (from left) are District 10 Director Richard Harris, AWS President Vic Matthews, and Mark Brereton, chairman of the Northwestern Pennsylvania Section.

Kevin Castnel, and **Huck Hughes**. District 10 welding scholarships were presented to **Stephanie Irvine**, **Erick Speer**, **Gregory Beck**, **Sam Johnson**, **Tim Zacharias**, and **Zach Boyd**. The meeting concluded with a tour of the Joy Mining Machinery facilities to study the assembly of equipment used in underground mining operations.

Topic: Careers in welding

Activity: This joint meeting of the Drake Well and Northern Pennsylvania Sections was held at Tri-State Business Institute in Erie, Pa. **Richard Harris**, District 10 director, presented **Craig Newell** the Section Meritorious Award, and **Mark Brereton** the Section Educator Award.

District 10

Richard A. Harris, director
(440) 338-5921

richaharris@windstream.net

District 10 Conference

MAY 8

Speaker: **Vic Matthews**, AWS president

Affiliation: The Lincoln Electric Co.

Topic: International growth

Activity: The meeting was held at Joy Mining Machinery in Franklin, Pa. **Richard Harris**, District 10 director, and **Brian McGrath**, AWS staff engineer, made presentations. Awards were presented to **Ward Kiser**, **Bob Brenner**, **Lon Damon**, **Scott Burdige**, **Dan Cyphersteen**,

DRAKE WELL NORTHWESTERN PA.

MARCH 31

Speaker: **Vic Matthews**, AWS president

Affiliation: The Lincoln Electric Co.

District 11

Eftihios Siradakis, director
(989) 894-4101

ft.siradakis@airgas.com



Top scorers in the Detroit Section's welding contest are (from left) Rigoberto Clemente, Ryan Baker, and Ryan O'Dette.



Representing the Detroit Section at the annual Quiz the Experts event were (from left) Steve Slavick, Andy Klos, and Don Maatz.



Shown at the Lakeshore Section sporting clay shoot outing are (from left) Chuck Frederick, David Ramseur, Theresa Wiles, Mike Urban, Bill Krcma, Lee Levenhagen, and (front) Jim Becker.



Detroit Section Vice Chair John Bohr (left) is shown with speaker Donald F. Maatz Jr.



Ben Newcomb (left) receives the District 12 Director Award from Rob Stinson at the Madison-Beloit Section meeting.

DETROIT

APRIL 20

Activity: The Section hosted the 16th annual District 11 Quiz the Experts event at Tony M's in Lansing, Mich., for more than 50 attendees. Participating were welding experts from the Detroit, Saginaw Valley, Central Michigan, and Western Michigan Sections and the Ferris State University Student Chapter. The Detroit Section team included **Steve Slavick**, **Andy Klos**, and **Don Maatz**.

MAY 14

Speaker: **Donald F. Maatz Jr.**, welding laboratory manager

Affiliation: RoMan Engineering Services
Topic: Material characterization for welding utilizing AWS standards

Activity: The winners of the Detroit Section's annual high school welding contest, held May 9, were presented their awards. The top three winners, **Ryan O'Dette**, **Rigoberto Clemente**, and **Ryan Baker**, received scholarships totaling \$4500. More than 40 people attended the program, held at the Ukrainian Cultural Center in Warren, Mich.

NORTHWEST OHIO

APRIL 2

Activity: The Section participated in the 13th Annual Lincoln Electric Welding Motor Sports program in Perrysburg, Ohio. **Karl Hoes**, a Lincoln Electric welding instructor, discussed the materials and welding processes used in motor sports vehicle fabrication. On display were competition vehicles from Owens C.C., University of Toledo, University of Northwest Ohio, and Bowling Green State University.

District 12

Sean P. Moran, director

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sean.moran@hobartbrothers.com

LAKESHORE

MAY 16

Activity: The Section hosted its annual sporting clay shoot at Triple J Game Farm and Sporting Clays in Reedsville, Wis. Section officers were elected for the new season.

MADISON-BELOIT

MAY 13

Activity: The Section's executive board members met to finalize business and announce the incoming slate of officers. Appointed are **Ben Newcomb**, chairman and technical representative; **Tony Stute**, vice chair, SENSE, and student affairs chair;

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President's Honor Roll: Recruit 1-2 new Individual Members and receive an AWS key chain.

President's Club: Recruit 3-8 new Individual Members and receive an AWS hat and an AWS key chain.

President's Roundtable: Recruit 9-19 new Individual Members and receive an AWS polo shirt, hat and an AWS key chain.

President's Guild: Recruit 20 or more new Individual Members and receive an AWS watch, an AWS polo shirt, a one-year free AWS Membership, the "Shelton Ritter Member Proposer Award" Certificate and membership in the Winner's Circle.

Winner's Circle: All members who recruit 20 or more new Individual Members will receive annual recognition in the *Welding Journal* and will be honored at FABTECH International & AWS Welding Show.

SPECIAL PRIZES

Participants will also be eligible to win prizes in specialized categories. Prizes will be awarded at the close of the campaign (June 2010).

Sponsor of the Year: The individual who sponsors the greatest number of new Individual Members during the campaign will receive a plaque, a trip to the 2010 FABTECH International & AWS Welding Show, and recognition at the AWS Awards Luncheon at the Show.

Student Sponsor Prize: AWS Members who sponsor two or more Student Members will receive an AWS key chain.

The AWS Member who sponsors the most Student Members will receive a free, one-year AWS Membership, an AWS polo shirt, hat and an AWS key chain.

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For every new member you sponsor, your name is entered into a quarterly drawing. The more new members you sponsor, the greater your chances of winning. Prizes will be awarded in November 2009, as well as in February and June 2010.

Prizes Include:

- ★ Complimentary AWS Membership renewal
- ★ AWS t-shirt
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SUPER SECTION CHALLENGE

The AWS Section in each District that achieves the highest net percentage increase in new Individual Members before the June 2010 deadline will receive special recognition in the *Welding Journal*.

The AWS Sections with the highest numerical increase and greatest net percentage increase in new Individual Members will each receive the Neitzel Membership Award.

*The 2009-2010 MGM Campaign runs from June 1, 2009 to May 31, 2010. Prizes are awarded at the close of the campaign.



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Last Name _____

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Title _____ Birthdate _____

Were you ever an AWS Member? ☐ YES ☐ NO If "YES," give year _____ and Member # _____

Primary Phone () _____ Secondary Phone () _____

FAX () _____ E-Mail _____

Did you learn of the Society through an AWS Member? ☐ Yes ☐ No

If "yes," Member's name: _____ Member's # (if known): _____

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PROFILE DATA

NOTE: This data will be used to develop programs and services to serve you better.

- ① Who pays your dues?: ☐ Company ☐ Self-paid ② Sex: ☐ Male ☐ Female
- ③ Education level: ☐ High school diploma ☐ Associate's ☐ Bachelor's ☐ Master's ☐ Doctoral

PAYMENT INFORMATION (Required)

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TWO-YEAR AWS INDIVIDUAL MEMBERSHIP†~~\$160~~ \$135



New Member? ☐ Yes ☐ No

If yes, add one-time initiation fee of \$12\$ _____

International Members add \$50 for optional hard copy of *Welding Journal* (note: digital delivery of *WJ* is standard)†††\$50 (Optional)

{ Domestic Members add \$25 for book selection (\$192 value), and save up to 87%††.....\$ _____ (Optional)
{ International Members add \$75 for book selection (note: \$50 is for international shipping) ††.....\$ _____ (Optional)
(Note: Book Selection applies to new Individual Members only – Book selections on upper-right corner)

TOTAL PAYMENT\$ _____

AWS STUDENT MEMBERSHIP †††

- ☐ Domestic (Canada & Mexico incl.)\$15
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TOTAL PAYMENT\$ _____

NOTE: Dues include \$18.70 for *Welding Journal* subscription and \$4.00 for the AWS Foundation.

Payment can be made (in U.S. dollars) by check or money order (international or foreign), payable to the American Welding Society, or by charge card.

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☐ *Welding Handbook (9th Ed., Vol. 3)*
☐ *Welding Handbook (9th Ed., Vol. 2)*
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☐ New Member ☐ Renewal

A free local Section Membership is included with all AWS Memberships.

Section Affiliation Preference (if known):

Type of Business (Check ONE only)

- A ☐ Contract construction
B ☐ Chemicals & allied products
C ☐ Petroleum & coal industries
D ☐ Primary metal industries
E ☐ Fabricated metal products
F ☐ Machinery except elect. (incl. gas welding)
G ☐ Electrical equip., supplies, electrodes
H ☐ Transportation equip. — air, aerospace
I ☐ Transportation equip. — automotive
J ☐ Transportation equip. — boats, ships
K ☐ Transportation equip. — railroad
L ☐ Utilities
M ☐ Welding distributors & retail trade
N ☐ Misc. repair services (incl. welding shops)
O ☐ Educational Services (univ., libraries, schools)
P ☐ Engineering & architectural services (incl. assns.)
Q ☐ Misc. business services (incl. commercial labs)
R ☐ Government (federal, state, local)
S ☐ Other

Job Classification (Check ONE only)

- 01 ☐ President, owner, partner, officer
02 ☐ Manager, director, superintendent (or assistant)
03 ☐ Sales
04 ☐ Purchasing
05 ☐ Engineer — welding
20 ☐ Engineer — design
21 ☐ Engineer — manufacturing
06 ☐ Engineer — other
10 ☐ Architect designer
12 ☐ Metallurgist
13 ☐ Research & development
22 ☐ Quality control
07 ☐ Inspector, tester
08 ☐ Supervisor, foreman
14 ☐ Technician
09 ☐ Welder, welding or cutting operator
11 ☐ Consultant
15 ☐ Educator
17 ☐ Librarian
16 ☐ Student
18 ☐ Customer Service
19 ☐ Other

Technical Interests (Check all that apply)

- A ☐ Ferrous metals
B ☐ Aluminum
C ☐ Nonferrous metals except aluminum
D ☐ Advanced materials/Intermetallics
E ☐ Ceramics
F ☐ High energy beam processes
G ☐ Arc welding
H ☐ Brazing and soldering
I ☐ Resistance welding
J ☐ Thermal spray
K ☐ Cutting
L ☐ NDT
M ☐ Safety and health
N ☐ Bending and shearing
O ☐ Roll forming
P ☐ Stamping and punching
Q ☐ Aerospace
R ☐ Automotive
S ☐ Machinery
T ☐ Marine
U ☐ Piping and tubing
V ☐ Pressure vessels and tanks
W ☐ Sheet metal
X ☐ Structures
Y ☐ Other
Z ☐ Automation
1 ☐ Robotics
2 ☐ Computerization of Welding

Dave Diljak, secretary; **Bill Dawson**, treasurer; **Dan Gibbs**, membership chair; **Paul Elmer**, publicity chair; and **Lochlan Masters** and **Bill Dawson**, webmasters. Member-at-Large **Rob Stinson** presented **Ben Newcomb** the District 12 Director Award.

MILWAUKEE

MAY 11-13

Activity: The Section members participated in the National Robotic Arc Welding Conference held at Milwaukee Area Technical College in Milwaukee, Wis., and an awards-presentation program. Activities featured tours of the Miller Electric Co. facilities in Appleton, Wis., and Caterpillar in Aurora, Ill. **Richard Litt** received the D16 Excellence in Robotic Arc Welding Award from **Jeff Noruk**, vice chair of the AWS D16 Committee on Robotic and Automatic Welding Committee. **Gerald Blaski** received an appreciation award for serving as chairman. The Silver Membership Award was presented to **David Sytkowski** for 25 years of service to the Society. Section scholarships were presented to **Shaparris Hill**, **Matthew Allickson**, **Anni Quackenbush**, **Derek Thommesen**, **Jina-Lin O'Donnell**, **Nathan Liszewski**, **Melissa Emmerson-Froebe**, and **Matthew Williams**. The conference attendance was 109 and 143 attended the meeting.



Richard Litt (left) accepts the D16 Excellence Award from Jeff Noruk at Milwaukee Area Technical College.



David Sytkowski (right) receives the Silver Membership Award from Gerald Blaski, Milwaukee Section chair.



Milwaukee Section scholarship recipients are (from left) Shaparris Hill, Matthew Allickson, Anni Quackenbush, Derek Thommesen, Jina-Lin O'Donnell, Nathan Liszewski, Melissa Emmerson-Froebe, and Matthew Williams.

District 13

W. Richard Polanin, director
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rpolanin@icc.edu

CHICAGO

MAY 13

Speakers: **Dave Thayer**, sales representative; and **Phil Bouchard**, regional manager

Affiliation: The Lincoln Electric Co.

Topic: Welding productivity improvements using advanced technology

Activity: The meeting was held for 35 attendees at the Lincoln Electric Co. facility in Bolingbrook, Ill.



Chuck Hubbard (center) is shown with speakers Dave Thayer (left) and Phil Bouchard at the Chicago Section program.



Gerald Blaski, Milwaukee Section chair, chats with Karen Gilgenbach, incoming chair.

J.A.K.

APRIL 18

Activity: The Section sponsored its first annual welding rodeo competition featuring three events open to welders of all skill levels. Nineteen welders participated. **Wade Surface** took first-place in the first event and **Joshua Karalevicz** took top honors in the second and third events. Chairman **John Willard**, a CWI, judged the contest. Other sponsors included Kankakee C.C., Pratt Gases and Welding Supplies, Accurate American Inspecting, Stevenson Fabrication, Belson Steel Center, and Lincoln Electric.



Shown at the J.A.K. Section welding rodeo are (from left) Joe Barry, Brad Doyle, Kraig Anderson, Tyler Claussen, Joe Blanchette, Nick Dumey, Wade Surface, Joshua Karalevicz, and Jeff Mandrala.



Indiana Section members working the Mid-West Welding Tournament are (from left) Mike Anderson, John Myers, Bennie Flynn, Dick Alley, Chair Tony Brosio, Dave Jackson, Gary Tucker, District 14 Director Tully Parker, Gary Dugger, and Bob Richwine.



Mid-West Tournament winners were (from left) Adam Buschkoetter, Jon Estey, Kyle Gudorf, Jamen Frederick, and Isaac Heeke.



Mid-West Tournament second-place scorers were (from left) Terry Creager, Derek Grove, Quinn Kurtz, Tom Folk, and Max Kramer.



The first-place SkillsUSA team is shown at the Lexington Section program.

District 14

Tully C. Parker, director
(618) 667-7795
tparke@millerwelds.com

INDIANA

APRIL 14-18

Activity: The Section hosted its 31st annual Mid-West Team Welding Tournament, a three-day event, in New Castle, Ind. This year, 21 five-member teams competed. Expediting and judging the event were District 14 Director **Tully Parker**, Chairman **Tony Brosio**, Past AWS President **Dick Alley**, **Mike Anderson**, **John Myers**, **Bennie Flynn**, **Dave Jackson**, **Gary Tucker**, **Gary Dugger**, and **Bob Richwine**. Taking first-place honors was the Pike Central team: **Adam Buschkoetter**, **Jon Estey**, **Kyle Gudorf**, **Jamen Frederick**, and **Isaac Heeke**. The second-place trophy went to the Four County team: **Terry Creager**, **Derek Grove**, **Quinn Kurtz**, **Tom Folk**, and **Max Kramer**.

LEXINGTON

APRIL 23

Activity: The Section hosted the state SkillsUSA welding competitions in Lexington, Ky. The top contenders were **Cody Warren**, **Chris Moyes**, **Jordan Harris**, and **Ormit Kelsey**. Past Chair **Frank McKinley** presented **Gordon Holl** an award for serving 17 years as treasurer. **Alan Mattox** was cited for his year of service as Section chair.

District 15

Mace V. Harris, director
(612) 861-3870
macevh@aol.com

NORTHERN PLAINS

APRIL 23

Activity: The Section hosted its annual Behind the Mask welding contest at Northland Community and Technical College in Thief River Falls, Minn. The work of the 52 contestants was judged by **Brent Smith** and **Jason Pachel** of Arctic Cat, Inc.; **Dennis Wilkens**, retired welding instructor; **Bryan Steiger** of Steiger Mfg.; **Mike Lindholm** of Lindholm Welding Inc.; **Ralph Williams** of Praxair; **Ron Palm** of Machinewell Inc.; and **Jamie Nelson** of Enbridge Energy.

SASKATOON

APRIL 9

Speaker: **Srinivasan Sethuraman**
 Topic: Road map to AWS D1.1:2008
 Activity: The meeting was held at Hitachi Canadian Industries Ltd., in Saskatoon, Saskatchewan, Canada.



Iowa Section Treasurer Pat Naylor instructs the welders on the rules of the contest.

District 16

David Landon, director
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dlandon@vermeermfg.com

IOWA

APRIL 23

Activity: The Section members toured PB Choppers in Moravia, Iowa, to study the operations in a small chopper manufacturing shop. **Jim and Shaun Wubben**, co-owners, conducted the tour.

MAY 1

Activity: The Iowa Section hosted the state SkillsUSA welding contest at Des Moines Area C.C. in Ankeny, Iowa. The judges included **John Hopwood, Tom Thompson, Pat Naylor, Charles Burg, Mike Meyers, Levi Taylor, and David Landon**, District 16 director. The top welders in the Secondary class were **Austin Golightly, Kyle Harding, and Nathan Evans**. Winning in the Postsecondary class were **Brandon VanderLeest, Megan Nyberg, and Tawnya Caruth**.

MAY 8

Activity: The Iowa Section held its annual golf outing at Prairie Knolls Country Club in New Sharon, Iowa, for nearly 40 attendees. The prize sponsors were Lincoln Electric, AirGas, AirGas Safety, Miller Electric, LinWeld, Tregaskiss, and Praxair. The players included District 16 Director **Dave Landon, Tony Forneris, Tom Beebe, Mike Carroll, Wayne Burns, Keith Van Hemert, Shaun Vincel, Randy Lewis, Paul Peterson, Jim Dugger, Steve Wenner, Brian Van Kooten, Norm Van Wyk, Kevin Stauners, Brad Lane, Brian Hipsher, Joe Chidester, Tim Peterson, Jason Roush, Mike Proffitt, Steve Parrish, Michael Byerly, Rick Guffey, Bobby Krutsinger, Tony Hibler, Jon Landon, Tom Landon, Tom Thompson, Ed Clawson, Eric Burns, Gerald Ricks, Paul Storm, and Jason Gross**.

SIOUXLAND

APRIL 28

Activity: Several Section members participated in the 2009 Career Exposition



Shown are the second-place contenders at the Lexington Section welding contest.



Taking first place in the Northern Plains Section's Behind the Mask welding contest are Nathan Lillis (left) and Kerry Pipo.



Frank McKinley, Gordon Holl, and Chair Alan Mattox are shown at the Lexington Section program.



Judging the Northern Plains Section's Behind the Mask welding contest were (from left) Jason Pachel, Dennis Wilkens, Bryan Steiger, Mike Lindholm, and Ralph Williams.



Shown at the Saskatoon Section program are (back row, from left) Warren Becker, Kevin Dyck, Curtis Henderson, and Robert Cobham; (front, from left) Dean McGowan, William Ho, speaker Srinivasan Sethuraman, Ike Oguocha, Shufeng Shen, and James Amanie.



Iowa Section members are shown during their tour of PB Choppers in April.



Most of the Iowa Section golfers posed for a group shot during their May 8 tournament.



Judges for the Iowa Section welding contest are (from left) John Hopwood, Tom Thompson, Pat Naylor, Charles Burg, Mike Meyers, Levi Taylor, and District 16 Director David Landon.



District 16 Director Dave Landon (right) presents an award to Bob Evans at the Siouxland Section program.

hosted by the Regional Technical Education Center in Yankton, S.Dak. Attending were 715 students from area schools who visited the 35 booths set up by various businesses. The Section's booth allowed students to try their hand at virtual reality welding courtesy of Vermeer



Dave Elsloo demonstrates virtual reality welding at the Career Expo in April.

Corp., Pella, Iowa. Manning the booth were **Josh Svatos**, vice chair, Iowa Section Secretary **Dave Elsloo**, and **Dave Landon**, District 16 director. Landon presented **Bob Evans** an award for outstanding service as advisor, Yankton Sr. High School Student Chapter.

District 17

J. J. Jones, director
(940) 368-3130
jjones@thermadyne.com

CENTRAL ARKANSAS

APRIL 13

Activity: The Section hosted the state of Arkansas SkillsUSA welding competition in Hot Springs, Ark. Participating were **George Seahorn**, **Chris Newell**, **D. J. Berger**, **Matt Fair**, **Mickey Porter**, **David Newell**, **Tori Huggins**, **Jim Ryan**, **Dennis Pickering**, **Jonathan Bibb**, **Jim Brewer**, and **Lee Danner**.

TULSA

APRIL 5

Activity: The Section provided judges for the Oklahoma state SkillsUSA welding competition. Participating were **Tim Cruse**, **Jim Lamore**, **Kenny Eden**, and coordinator **John Knapp**.

APRIL 28

Activity: The Tulsa Section members toured the DMI Industries facility in Tulsa, Okla., to study the manufacture of wind towers for generating electricity. **Gary Williams**, general manager, conducted the program.

District 18

John Bray, director
(281) 997-7273
sales@affiliatedmachinery.com



Shown at the Central Arkansas welding competition are (from left) George Seahorn, Chris Newell, D. J. Berger, Matt Fair, Mickey Porter, David Newell, Tori Huggins, Jim Ryan, Dennis Pickering, Jonathan Bibb, Jim Brewer, and Lee Danner.



Shown at the British Columbia Section program are (from left) Chair Pat Newhouse, speaker John Davidson, and Wayne Brox, ASM chapter chairman.



Shown at the Tulsa Section tour are (from left) Vice Chair Adam Enslinger, presenter Gary Williams, and Chairman Jamie Pearson.



Tulsa Section judges in the Oklahoma state welding competition were (top, from left) Tim Cruse and John Knapp; (front, from left) Jim Lamore and Kenny Eden.

HOUSTON

APRIL 23

Activity: The Section held its annual golf tournament at Golfcrest Country Club in Pearland, Tex., for 56 entrants. **John Bray**, District 18 director, attended the event.

RIO GRANDE VALLEY

MAY 17

Activity: The AWS Districts Council approved the Section's charter.



Tulsa Section members are shown during their tour of DMI Industries April 28.

District 19

Neil Shannon, director
(503) 419-4546
neilshnn@msn.com

ALASKA

APRIL 17

Activity: The Section held a planning meeting to set up the next season's calendar of events, scholarships for welding students **Heather Strong** and **Anthony Tressler**, upcoming leadership and instructor conferences, and a review of Section bylaws. The meeting was held at Peggy's Restaurant in Anchorage, Alaska.

BRITISH COLUMBIA

APRIL 22

Speaker: **John Davidson**, P.E., materials and corrosion group manager
Affiliation: Levelton Consultants
Topic: Comparison of various interna-



Shown at the Houston Section golf outing are (from left) Greg Hartwig, Ron Theiss, John Pearson, Justin Gordy, and Derek Stelly.

tional bridge designs with Canadian bridge code requirements

Activity: This was a joint meeting with members of the local chapter of ASM International, **Wayne Brox**, chairman. Attending were **Chuck Daily** and **Jerry Hope** from the Puget Sound Section. The program, conducted by Chair **Pat**

Newhouse, was held at Ricky's All Day Grill in Surrey, B.C.

OLYMPIC

MAY 13

Activity: The Section's board members met in Tacoma, Wash. Attending



Colorado Section members are shown at the ESAB-sponsored program held at Pickens College.



Shown at the Utah Section program are (from left) host and sponsor Rex Harrison, Chair Woody Cook, and speaker Wade Laycock.



Kelly Newton (left) and Bob Newsome discussed welding and cutting technology at the Colorado Section program.



Olympic Section executive board members take a break during their May meeting.



Speaker Doug Biron (left) is shown with Ken Johnson, Puget Sound Section vice chair.



Shown at the March 2 SkillsUSA contest are Arizona Western College Student Chapter members (from left) Chair Alexis Favela, Travis McCollum, Steve Seale, and Gilbert "Ed" Garcia, vice chair.

were **Bob Plummer**, **Rob Rothbauer**, **Marvin Nitta**, **Robyn Westphal**, **Sjon Delmore**, **Chris Hobson**, and **John Powers**. **Jerry Hope** from the Puget Sound Section attended the program.

PUGET SOUND

APRIL 2

Speaker: **Doug Biron**, representative
Affiliation: Bortech Corp. and York Portable Machine Tools

Topic: Bore and surface welding repair procedures

Activity: The talk included demonstrations of the equipment and programming. The meeting was held at Rock Salt Steak House in Seattle, Wash.

District 20

William A. Komlos, director
(801) 560-2353
bkoz@arctechllc.com

COLORADO

APRIL 9

Speakers: **Kelly Newton** and **Bob Newsome**, regional and territory sales managers, respectively

Affiliation: ESAB Welding and Cutting
Topic: New welding and plasma arc cut-

ting technologies

Activity: ESAB sponsored the meeting at Pickens Technical College in Aurora, Colo., for 41 attendees.

UTAH

APRIL 23

Speaker: **Wade Laycock**, bridge inspector

Affiliation: Utah Dept. of Transportation
Topic: The AWS D1.5, *Bridge Welding Code*, fabrication and inspection

Activity: **Richard "Woody" Cook** received a certificate of appreciation for his services as chair. **Rex Harrison**, with Utah Pacific Bridge & Steel, received a host and sponsor certificates of appreciation.

District 21

Nanette Samanich, director
(702) 429-5017
Nan07@aol.com

Arizona Western College Student Chapter

MARCH 2

Activity: The AWC Student Chapter, **Samuel Colton**, advisor, held its annual Take Up the Torch cutting skills competition at WestAir Gases & Equipment Inc. in Yuma, Ariz. The event involved more than 50 area high school and college students and family members. The projects were to cut a ring off the top of a 6-in.-diameter Schedule 40 pipe that is welded to a stand in the 2G position, and try for the fastest time cutting a heavy bar of solid stock. Another popular contest celebrated those who consumed four hot dogs in the shortest time. The Student Chapter is affiliated with the San Diego Section.

MARCH 6

Activity: The AWC Student Chapter hosted the SkillsUSA Region 1 welding skill competition at the college. Chapter members cut and prepared all of the test plates, set up the equipment, and assisted with the scoring of the contest with the contest committee members. The contest chair was **David Sanchez**, CWI/CWE, owner of Arc Dynamics of Yuma, Ariz.

MARCH 31–APRIL 5

Activity: AWC Student Chapter members **Gilbert “Ed” Garcia**, **Anthony Carroll**, **Steve Seale**, **Omar Trevino**, **Shanen Aranmor**, and **Samuel Colton**, advisor, manned an information booth at the Yuma County Fair. They answered passersby’s questions about welding and the college, and distributed the AWS publication *Your Career in Welding*. Featured was the video *Welding Holds the World Together*.

APRIL 24, 25

Activity: The AWC Student Chapter members took a field trip to San Diego, Calif., to study the welding applications at several industrial locations. The first day featured a tour of United Launch Alliance, led by welding engineer **Jose Aguirre**, to see rocket fuel cell fabrication. Next, they visited General Dynamics National Steel and Shipbuilding Co. (NASSCO) for a tour led by engineer **Randy Doerksen**, and an inspirational talk presented by **Art Serpa**, NASSCO vice president. The next day, they visited WestAir Gases to study its computerized bulk gas-fill plant. They learned about the welding opportunities available in the gas industry from **Pat Dalton**, general manager. SeaWorld San Diego was the final stop for a self-guided tour to study the many applications for welding in the theme park’s rides and water-based attractions.



The AWC Student Chapter members shown at the United Launch Alliance are (kneeling, from left) **Shanen Aranmor** and **Shawn Hayden**; (standing, from left) **Anthony Carroll**, Advisor **Samuel Colton**, **Jose Aguirre**, **Herman Quiroga**, **Kevin Estrada**, **Gilbert “Ed” Garcia**, and **David Guerra**.



AWC Student Chapter members are shown at the NASSCO complex. Standing, from left, are **Gilbert “Ed” Garcia**, tour guide **Randy Doerksen**, **Shanen Aranmor**, **Shawn Hayden**, **Kevin Estrada**, **Anthony Carroll**, and **Herman Quiroga**; (kneeling, from left) **Steve Seale** and **David Guerra**.



The AWC Student Chapter members shown at the WestAir facility are (standing, from left) **Pat Dalton**, Advisor **Samuel Colton**, **Herman Quiroga**, **Anthony Carroll**, and **Kevin Estrada**; (kneeling, from left) **Shawn Hayden**, **Gilbert “Ed” Garcia**, and **David Guerra**.



Chair **Liisa Pine** receives an appreciation certificate from Secretary **James Bulgerin** at the San Francisco Section program.



Speaker **Mike Bernasek** is shown with Chair **Liisa Pine** at the San Francisco Section meeting.

District 22

Dale Flood, director
(916) 288-6100, ext. 172
flashflood@email.com

SAN FRANCISCO

MAY 6

Speaker: **Mike Bernasek**, president, CEO
Affiliation: C-SPEC Corp.
Topic: Managing welding documentation

using **WeldOffice®** software

Activity: **James Bulgerin**, Section secretary, presented **Liisa Pine** a certificate of appreciation for her services as chairman for the past year.

Guide to AWS Services

American Welding Society
550 NW LeJeune Rd., Miami, FL 33126
www.aws.org; (800/305) 443-9353; FAX (305) 443-7559
Staff telephone extensions are shown in parentheses.

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Webster, Chamberlain & Bean, Washington, D.C., (202) 785-9500; FAX (202) 835-0243. Identifies funding sources for welding education, research, and development. Monitors legislative and regulatory issues of importance to the welding industry.

CONVENTION AND EXPOSITIONS

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Organizes the annual AWS Welding Show and Convention, regulates space assignments, registration items, and other Expo activities.

Brazing and Soldering Manufacturers' Committee

Jeff Weber.. jweber@aws.org(246)

RWMA — Resistance Welding Manufacturing Alliance

Manager
Susan Hopkins.. susan@aws.org(295)

WEMCO — Welding Equipment

Manufacturers Committee
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Welding Handbook Editor
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Director, National Standards Activities
John L. Gayler.. gayler@aws.org(472)
Personnel and Facilities Qualification, Computerization of Welding Information

Manager, Safety and Health
Stephen P. Hedrick.. stevch@aws.org (305)
Metric Practice, Safety and Health, Joining of Plastics and Composites, Welding Iron Castings

Technical Publications
AWS publishes about 200 documents widely used throughout the welding industry.

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Automotive Welding, Resistance Welding, Oxygen Gas Welding and Cutting, Definitions and Symbols, Sheet Metal Welding

Stephen Borrero.. sborrero@aws.org(334)
Joining of Metals and Alloys, Brazing and Soldering, Brazing Filler Metals and Fluxes, Brazing Handbook, Soldering Handbook

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Selvis Morales.. smorales@aws.org(313)
Welding Qualification, Structural Welding

Matthew Rubin.. mrubin@aws.org(215)
Aircraft and Aerospace, Machinery and Equipment, Robotics Welding, Arc Welding and Cutting Processes

Reino Starks.. rstarks@aws.org(304)
Welding in Sanitary Applications, High-Energy Beam Welding, Friction Welding, Railroad Welding, Thermal Spray

Note: Official interpretations of AWS standards may be obtained only by sending a request in writing to the Managing Director, Technical Services. Oral opinions on AWS standards may be rendered. However, such opinions represent only the personal opinions of the particular individuals giving them. These individuals do not speak on behalf of AWS, nor do these oral opinions constitute official or unofficial opinions or interpretations of AWS. In addition, oral opinions are informal and should not be used as a substitute for an official interpretation.

Nominees for National Office

Only Sustaining Members, Members, Honorary Members, Life Members, or Retired Members who have been members for a period of at least three years shall be eligible for election as a director or national officer.

It is the duty of the National Nominating Committee to nominate candidates for national office. The committee shall hold an open meeting, preferably at the Annual Meeting, at which members may appear to present and discuss the eligibility of all candidates.

To be considered a candidate for the positions of president, vice president, treasurer, or director-at-large, the following qualifications and conditions apply:

President: To be eligible to hold the office of president, an individual must have served as a vice president for at least one year.

Vice President: To be eligible to hold the office of vice president, an individual must have served at least one year as a director, other than executive director and secretary.

Treasurer: To be eligible to hold the

office of treasurer, an individual must be a member of the Society, other than a Student Member, must be frequently available to the national office, and should be of executive status in business or industry with experience in financial affairs.

Director-at-Large: To be eligible for election as a director-at-large, an individual shall previously have held office as chairman of a Section; as chairman or vice chairman of a standing, technical, or special committee of the Society; or as a District director.

Interested persons should submit a letter stating which office they seek, including a statement of qualifications, their willingness and ability to serve if nominated and elected, and a biographical sketch.

E-mail the letter to gricelda@aws.org, c/o Gene Lawson, chair, National Nominating Committee.

The next meeting of the National Nominating Committee is scheduled for November 2009. The terms of office for candidates nominated at this meeting will commence January 1, 2011.

profession, or to one who is accredited with exceptional accomplishments in the development of the welding art, upon whom the Society deems fit to confer an honorary distinction. Honorary Members have full rights of membership.

National Meritorious Certificate Award

This certificate award recognizes the recipient's counsel, loyalty, and dedication to AWS affairs, assistance in promoting cordial relations with industry and other organizations, and for contributions of time and effort on behalf of the Society.

International Meritorious Certificate Award

This honor recognizes recipients' significant contributions to the welding industry for service to the international welding community in the broadest terms. The awardee is not required to be an AWS member. Multiple awards may be given. The award consists of a certificate and a one-year AWS membership.

AWS Publications Sales

Purchase AWS standards, books, and other publications from **World Engineering Xchange (WEX), Ltd.**
orders@awspubs.com; www.awspubs.com
 Toll-free (888) 935-3464 (U.S., Canada)
 (305) 824-1177; FAX (305) 826-6195

Welding Journal Reprints

Copies of *Welding Journal* articles may be purchased from Ruben Lara.
 (800/305) 443-9353, ext. 288; rlara@aws.org

Custom reprints of *Welding Journal* articles, in quantities of 100 or more, may be purchased from

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AWS Foundation

AWS Foundation, Inc., is a not-for-profit corporation established to provide support for educational and scientific endeavors of the American Welding Society. Information on gift-giving programs is available upon request.

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Executive Director, AWS
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Executive Director, Foundation
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AWS Mission Statement

The mission of the American Welding Society is to advance the science, technology, and application of welding and allied processes, including joining, brazing, soldering, cutting, and thermal spraying.

It is the intent of the American Welding Society to build AWS to the highest quality standards. Your suggestions are welcome. Please contact any staff member or AWS President Victor Y. Matthews, as listed on the previous page.

Honorary Meritorious Awards

The Honorary Meritorious Awards Committee makes recommendations for the nominees presented to receive the Honorary Membership, National Meritorious Certificate, William Irrgang Memorial, and the George E. Willis Awards. These honors are presented during the FABTECH International & AWS Welding Show held each fall. The deadline for submissions is December 31 prior to the year of the awards presentations. Send candidate materials to Wendy Sue Reeve, secretary, Honorary Meritorious Awards Committee, wreeve@aws.org; 550 NW LeJeune Rd., Miami, FL 33126. Descriptions of these awards follow.

William Irrgang Memorial Award

Sponsored by The Lincoln Electric Co. in honor of William Irrgang, the award, administered by AWS, is given each year to the individual who has done the most over the past five years to enhance the Society's goal of advancing the science and technology of welding. It includes a \$2500 honorarium and a certificate.

George E. Willis Award

Sponsored by The Lincoln Electric Co. in honor of George E. Willis, the award, administered by AWS, is given each year to an individual who promoted the advancement of welding internationally by fostering cooperative participation in technology transfer, standards rationalization, and promotion of industrial goodwill. It includes a \$2500 honorarium and a certificate.

Honorary Membership Award

The honor is presented to a person of acknowledged eminence in the welding

NEW

LITERATURE

**ArcFlash™ Faceshield
Described in Product Sheet**



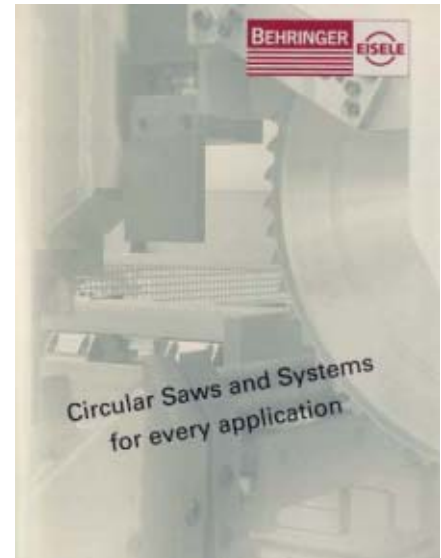
A full-color product sheet illustrates and presents the features of the company's new ArcFlash™ faceshield product line.

The models offer low-level arc flash protection featuring a specially formulated antifog window that provides superior color definition and physical protection that exceeds industry product standards. The sheet may be downloaded online.

Sellstrom Mfg. Co.
www.sellstrom.com
(800) 323-7402

**Industrial Saws Pictured
in Brochure**

A six-page, full-color, fold-out brochure illustrates and details the company's lines of industrial circular cold saws and miter saws for fine finish cutting of metals. Shown are semiautomatic and fully automatic models with high precision linear guides and ball bearing construction, hydraulic clamping, servo-driven axes for precise material positioning, models with precise ball screw spindles and fast servo-motors for precision cuts in seconds, and a circular cold saw for use with carbide-tipped blades. Technical



data are provided in chart form for simplified comparison of the various models. Pictured options include electronic length-measuring system, roller conveyor with measuring system, bundle loading magazine, tiltable roller conveyor to sort

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**We make companies, small or large,
Stand Out.**



About AWS Corporate Memberships:

The American Welding Society (AWS), understands that one size does not fit all. For that reason, we've created **FOUR** different levels of corporate membership, starting for as little as \$150 per year, allowing you to select a program that best fits with the way your company operates. With an 88-year history in the welding industry, and 50,000+ members worldwide, AWS Corporate Membership offers your company the ability to **INCREASE ITS EXPOSURE and IMPROVE ITS COMPETITIVE POSITION.**



American Welding Society

Contact Us:

CALL US FOR MORE INFORMATION, OR TO JOIN AT:
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AND NOW IT'S
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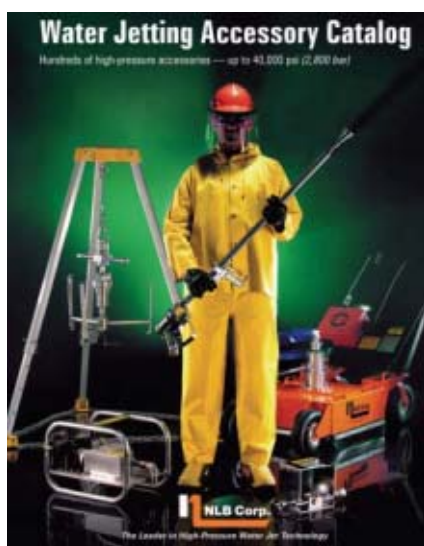
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trim cut, and rest piece, belt conveyor with multiple sorting positions for use as an interface to deburring, signing, or robot systems, and chain conveyor models for longer pieces.

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High-Pressure Cleaning Catalog Released



A 102-page catalog introduces a variety of waterjet tools for pipe cleaning, pavement marking removal, and other applications. Among the new accessories are Typhoon™ self-rotating nozzles for cleaning pipes and tubes with diameters from ½- to 50-in., and a new 40,000-lb/in.² Spin-Nozzle® head. New system valve rebuild kits feature a cartridge-style seal that can be changed quickly. Introduced is the Starjet-Plus™ automated pavement maintenance system with many improvements. Included are a comprehensive couplings and fittings section, reference section with hook-up drawings, nozzle flow charts, thrust and pressure-drop tables, and English to metric conversions. The catalog may be downloaded from the Web site or call to request a free hard copy.

NLB Corp.
www.nlbcorp.com
(248) 624-5555

Mastering Light DVD Updated

Mastering Light — An Introduction to Laser Safety & Hazards covers the basic fundamentals of laser safety including beam hazards, control measures, bioef-

fects, classifications, nonbeam hazards, and other topics in a 23-minute DVD updated for 2009. It is described as a cost-efficient and effective training tool and resource for laser safety officers who train new employees, and for laser operators, researchers, and students. The DVD fulfills the requirements of ANSI Z136.1, *Safe Use of Lasers*, and OSHA requirements for training employees who work with or near Class 3B or Class 4 lasers and laser systems. The list price is \$495, \$450 for association members. For more information or to order, call or visit the Web site. For a free preview of the DVD, visit www.laserinstitute.org/media/masteringlight.php.

Laser Institute of America
www.laserinstitute.org
(800) 345-2737

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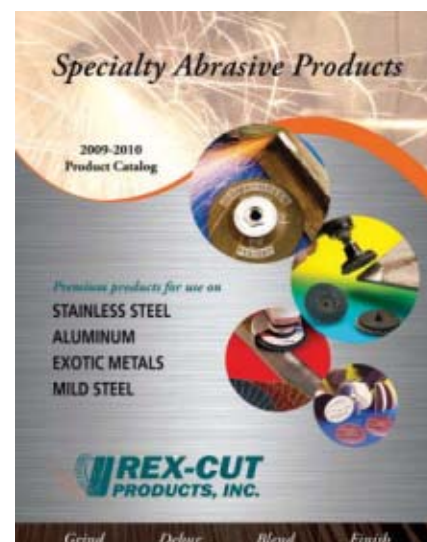
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New Web Site Features Technical Case Studies

The updated Web site now features dozens of case studies and technical papers that provide engineering expertise about hydraulics, pneumatics, conveyors, linear motion, drives, controls, and boosting energy efficiency. Typical titles, downloadable as PDFs, are Boost Energy Efficiency in Industrial Machines with Pneumatics Optimization, and Total Cost of Ownership and Linear Motion; plus papers on programming automated systems. From the main page, one can navigate to either the case study or technical papers library and sort by technology, industry, or topic.

Bosch-Rexroth
www.boschrexroth-us.com/stories
(800) 739-7684

Abrasive Products Pictured in New Catalog



The 26-page, full-color, well-illustrated *Specialty Abrasive Products Catalog 2009-2010* features products for coarse-to-light stock removal, deburring, edge-breaking, blending, finishing, and maintenance. The new product index is categorized by product type with symbols depicting the style of grinder each product is designed for. Included is a wide range of cutting, grinding, blending, and finishing products for use with stainless steel, mild steel, aluminum, exotic metals, and certain fiberglass composites. Product listings include complete specifications, dimensions, and suggested applications. Detailed are the advantages of abrasive impregnated cotton fiber abrasive products.

Rex-Cut Products, Inc.
www.rexcut.com
(800) 225-8182

New Standard Addresses Crane Inspectors

ISO 23814:2009, *Cranes — Competency requirements for crane inspectors*, specifies the competency required of persons who carry out periodic, exceptional, alteration, and thorough inspections of cranes. It excludes the day-to-day inspection and checks performed by crane operators and maintenance personnel. Addressed are independence, impartiality, and integrity; technical knowledge and experience; techniques for crane inspection; and training of crane inspectors. The objective of this standard is to achieve a uniformly high competency of crane inspectors worldwide. To order, visit the ISO Web site store.

ISO Central Secretariat
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CONFERENCE ON WELDING CHROME MOLY STEELS

The welding of chrome-moly steel goes back to the days when tubing was oxyacetylene-welded to make up the fuselages of the early pre-aluminum airplanes. It required outstanding precision on the part of the welder. Even though the methods have changed, the welding of chrome-moly steel still requires utmost precision on the part of the welder and all involved parties.

Heat treatment and nondestructive testing are part and parcel of a successful weld. The 2 1/4Cr-1Mo steels are very popular materials for boilers and pressure vessels where the ASME Code is used. More recently, the modified 9Cr-1Mo steel, which was originally developed as the base metal for the Fast Breeder Reactor, is now widely specified in electric utilities and is moving into the oil and gas industry. To weld any of these steels for the first time, the engineer and the welder actually have to go back to school and start all over again.

Conventional arc welding processes are all used effectively on 4130, 2 1/4Cr-1Mo, and modified 9Cr-1Mo steels. Some newer processes like hybrid welding have also become popular. Proper administration of the preheat and postweld heat treat operations is most critical.

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Tuesday, Nov. 17, 2009

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PERSONNEL

Welding Research Chair Established at Alberta U.



Patricio Mendez

The University of Alberta has named **Patricio F. Mendez** the inaugural Weldco/Industry Chair in Welding and Joining in the Department of Chemical and Materials Engineering. This new industrial research chair will be the cornerstone of the Canadian Centre for Welding and Joining where Mendez will also serve as director. The center will focus on productivity, weldability, automation, performance, processes, materials, difficult-to-weld materials such as aged and embrittled alloys, nondestructive testing, corrosion, and fracture.

Deckrow Elected WEMCO Chairman



Jeff Deckrow

The Welding Equipment Manufacturers Committee (WEMCO), an American Welding Society standing committee, has elected **Jeff Deckrow** chairman. Deckrow joined Hypertherm, a supplier of plasma cutting systems, in 1994, where he currently serves as director, North America, responsible for sales support nationwide and Canada. He serves on the AWS Publications, Expositions, and Marketing Committee (PEMCO), and has worked with the Gases and Welding Distributors Assn. (GAWDA), where he served as a board member and chairman of the Industry Partnering Committee.

U.S. Steel Makes Management Changes

United States Steel Corp., headquartered in Pittsburgh, Pa., has named **Steven A. McFatridge** general manager — raw materials for the company's European operations in the Slovak Republic and the Republic of Serbia. **William J. McFadden** has replaced McFatridge as general manager — raw materials for North American operations. McFatridge began his career with

U.S. Steel in 1974 and has served in numerous positions in accounting, finance, purchasing, and business planning. McFadden previously served as manager — raw materials at the corporate headquarters.

Delany Joins French Welding Institute



Fred Delany

Fred Delany has joined the executive board of the Institut de Soudure, Paris, France, as director of international operations. Prior to joining the institute, Delany worked 20 years for The Welding Institute, UK, in various international business development positions in welding and nondestructive testing services.

CenterLine (Windsor) Hires General Manager



Doug Matton

CenterLine (Windsor) Ltd., Windsor, Ontario, Canada, has appointed **Doug Matton** general manager, supersonic spray technologies division. Matton, in the industry for 25 years, has held positions in process and controls engineering, plant and executive management, with experience in process and product development and research and development in both automotive and nonautomotive industries.

Meta Vision Appoints Director of Sales



Stephen Thacker

Meta Vision Systems Inc., Montreal, Canada, a manufacturer of laser- and camera-based systems for automating welding and production processes, has named **Stephen Thacker** director of sales for North America. Thacker previously worked as director of sales for StockerYale Canada, a supplier of laser modules used in the machine vision industry.

Assn. for Mfg. Technology Elects President



Douglas Woods

The Association for Manufacturing Technology (AMT), McLean, Va., has elected **Douglas K. Woods** president. Woods previously was president of Parlec, Inc., a company that specializes in tooling, work-holding, and presetting solutions. Woods served as a member of AMT's board of directors 2000–2008, and was chairman 2005–2006.

Laser Cladding Fills Three Key Posts

Laser Cladding Services, Houston, Tex., has appointed **Theron Metz** general manager, **Mary Lamb** account manager for a variety of the company's clients, and **Jim Kowske** vice president of business development for parent company Gremada Industries. Metz has ten years of experience, most recently as a business unit manager for a process equipment business; Lamb brings 15 years of oil and gas experience in selling coating solutions for oil tools.

Automation Manager Named at Centennial Tech



John Nelson

Centennial Technologies, Inc., Saginaw, Mich., has appointed **John Nelson** automation manager. He is responsible for management and sales of robotics and automation systems projects worldwide. Nelson has 17 years of experience in the industry, including service with KUKA Robotics.

Bishop-Wisecarver Expands Spanish Services

Bishop-Wisecarver Corp., Pittsburg, Calif., a provider of guided motion components and systems for linear, rotary, and curved track applications, has appointed **Ricardo Iraheta** a customer service repre-

— continued on page 98

The Emmet A. Craig Resistance Welding School

Sponsored by the American Welding Society and the Resistance Welding Manufacturing Alliance (RWMA)

is coming to Chicago!

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Each year, this two-day resistance welding school is attended by seasoned professionals, shop supervisors, production managers, electrical engineers, and mechanical engineers. Sessions on the basics of resistance welding and real-life applications of the process are conducted by industry specialists with extensive resistance welding experience. Participants are able to learn at their own pace, discuss specific welding concerns with the instructors, and are invited to bring their own samples for discussion. In addition, attendees can visit with RWMA-member companies during tabletop exhibit lunches to learn about the latest resistance welding products being offered.

For the latest information on the RWMA Welding School visit our website at www.aws.org/show/rwma.html or call 800-443-9353, ext. 455

To register online, go to www.aws.org/show/rwma.html and click on **REGISTER**



PERSONNEL

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sentative to conduct business in Spanish or English. Iraheta, originally from El Salvador, holds a mechanical engineering degree from the University of California at Santa Barbara. The company has appointed additional bilingual customer service representatives to assist clients in the South Florida and Caribbean regions. In support, the company is creating a library of Spanish-language versions of its more popular catalogs and literature.

Obituary

Shelton L. Ritter



Shelton L. Ritter

Shelton Leo Ritter, 89, died May 15. An active AWS member since 1947, and a Distinguished Member, he served in all of the elected offices within the New Orleans Section and District 9, remaining involved until Hurricane Katrina destroyed his home in 2005. He served as the AWS national membership chairman for many years, and signed up so many new members year after year that the Member Proposer Award was named in his honor.

Ritter, a decorated infantryman, saw active duty during WW II in North Africa, Sicily, Italy, and Germany under Generals Mark Clark and George Patton.

Ritter began his welding career in 1947 as a technical sales representative for Gulf Welding Equipment. In 1974, he joined Braun Welding Supply, where he specialized in major equipment sales to large industrial customers. Later, in 1982, he became specialty alloy manager at Doussan, Inc., where he concentrated on sales to power-production plants and aerospace industries nationwide and in Canada. Though he retired in 1992, Ritter remained an active member on the New Orleans Section executive board and as a senior technical consultant for Gas Technology Consultants, Inc.

The New Orleans Section, in conjunction with the AWS Foundation, Inc., has established The Shelton L. Ritter Memorial Scholarship Award to assist students studying welding engineering. He is survived by daughters Linda, Therese, and Gloria Ann, nine grandchildren, and seven great-grandchildren.

Pipe Cutting and Related Tools Pictured



An 80-page, full-color catalog presents the company's complete lines of general pipe-working tools, wrenches, plastic pipe tools, water service tools and machines, vises, groovers, power drives, threaders and dies, cutting tools and cutting wheels. Included are six pages of new tools and eight pages of Best Ever! tools including large-diameter ratchet wrenches, smooth jaw wrenches and pliers, power tapping and drilling machines, and PEX tools. The PDF catalog may be downloaded from the Web site. Type "Catalog M" in the search window, or request a copy by mail.

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Aluminum Standards Updated

The 2009 editions of several industry standards for aluminum, known formally as ANSI H35, *American National Standards on Aluminum and Aluminum Alloys*, have been updated and are available for purchase. The standards provide the basis for all United States aluminum industry alloy and temper designations, product standards, and alloy-temper registrations, many of which are used worldwide. The revisions include changes to clarify impurity limits for ingot and castings to which they apply and the addition of definitions for T7x designations, changes to the defi-

NEW LITERATURE

— continued from page 94

nition of Foil for harmonization with the international definition, and resulting modifications to the definition of Sheet. The standards can be ordered online or by phone.

The Aluminum Association
www.aluminum.org/bookstore
(301) 645-0756

AWS Welding Certification Programs Detailed



A full-color brochure details the American Welding Society's complete catalog of certification seminars and exams. Fully explained are D1.1 Code Clinic, API 1104 Code Clinic, Welding Inspection Technology Workshop, 9-Year Recertification Seminar, Certified Welding Sales Representative, Certified Welding Supervisor Seminar, Certified Welding Educator (CWE), Visual Inspection Workshop, and CWI and CWE Examinations. Included are detailed descriptions of each program, all prices, fees, qualification requirements, and the 2009 seminar and exam schedule.

American Welding Society
www.aws.org/certification
(800) 443-9353, ext. 273

NEWS OF THE INDUSTRY

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Also, because this facility will now handle regular commercial and industrial deliveries for Orange County customers, to meet this increased demand, staff will be expanded with the creation of more than 30 positions. "To be able to bring these new jobs to the Riverside area — where we've just celebrated our third anniversary — is very rewarding for us," said Eric Steinhauer, IMS president.

The company is reconfiguring its Irvine, Calif., facility into a full-service retail storefront. With these changes, it is positioning for future expansion with the addition of retail storefront facilities throughout the region.

Williamsburg Technical College Hosts Welding Competition



Winners, sponsors, and instructors involved in Williamsburg Technical College's welding contest included (from left) instructor Jeff Ball; students Lance Howard, Myron Powell, Jay Owens, Kyle Howard, Calvin Scott Jr., and Antwuan Nelson; sponsors and judges Richie Jennings and Bob Meltzer with Peddinghaus; and instructor Jason Kinder.

The welding department of Williamsburg Technical College, Kingstree, S.C., recently hosted a welding competition to provide students the opportunity to receive critiques from local welding professionals to better prepare them for the workforce.

First-semester students who competed in one welding procedure, listed in order of first, second, and third place, were Kyle Howard, Calvin Scott Jr., and Antwuan Nelson. Also, advanced students who competed in three welding procedures included Jay Owens, first place; Myron Powell, second place; and Lance Howard, third place.

Welding instructors Jeff Ball and Jason Kinder invited plant manager Bob Meltzer and Certified Welding Inspector Richard Jennings, both from Peddinghaus Corp. of South Carolina, to serve as judges. Stephen Touchberry with Southern Welders, Sumter, S.C., and Robert Fender with National Welders provided prizes for the three top place winners in each of two categories. Peddinghaus provided materials for the competition as well.

ABB Awarded Frame Order for Robots

ABB Robotics, Auburn Hills, Mich., has signed an agreement with BMW Group to deliver 2100 industrial robots over five years, beginning in 2010. The carmaker's operations in Germany, the United Kingdom, and the United States will be supported. The robots will be applied in spot welding, parts handling, and gluing on car-body assembly lines for BMW's 1-series, 3-series, X5-series, and Mini models.

Pipe and Valve Technology Institute Opens New Training Center



The Pipe and Valve Technology Institute, Lake Zurich, Ill., has opened a training center and now offers two programs. Displayed above is hands-on training using outside-mounted cutting systems for prepping heavy-wall pipes. The valve operation maintenance and vacuum excavation courses are designed to provide training in the municipal water systems industries. The pipe cutting and weld prep program is designed to provide training for personnel working in power plant maintenance, oil refineries, petrochemical, process piping, high-purity systems, and government/military.

Industry Notes

- **Praxair Distribution Inc.** has acquired Alabama Welding Supply, Dolomite, Ala.; Fowler Brothers, Birmingham, Ala.; and Service Gas Supply, Inc., Midlothian, Tex.
- The U.S. Chamber of Commerce recently presented a 2009 Blue Ribbon Small Business Award to **Performance Welding, Inc.**, Freedom, Wis.
- **ATI Industrial Automation**, Apex, N.C., has received Managing Automation Media's Progressive Manufacturing 100 Award for its implementation of a new serial number tracking system.
- As part of its 20th year celebration, **In-House Solutions**, Cambridge, Ont., Canada, has a new logo. The company improves manufacturers' productivity in CNC and robotic programming.
- **Hypertherm**, Hanover, N.H., is among 40 winners of the 2009 WorldBlu List of Most Democratic Workplaces™ award sponsored by WorldBlu, Austin, Tex.
- The fabrication department of **CEMCO**, Albuquerque, N.Mex., has completed its AWS D1.1, *Structural Welding Code — Steel*, certification for A-36 plate and A514 grade B (T-1) plate.
- Tubing manufacturer **RathGibson** has opened an office in Buenos Aires, Argentina, led by Cristian Rohde, director — business development for Central and South America.
- **KUKA Roboter GmbH** has formed a wholly owned subsidiary in Canada that will serve users by providing local sales, services, and support.
- The **Aluminum Association** recently held its spring meeting in Arlington, Va. The two-day conference included a board of directors meeting, standing committee and division meetings.

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Preparation of Manuscripts for Submission to the *Welding Journal* Research Supplement

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- ◆ What is the significance of your results?
- ◆ What are your most important conclusions?

With those questions in mind, most authors can logically organize their material along the following lines, using suitable headings and subheadings to divide the paper.

1) **Abstract.** A concise summary of the major elements of the presentation, not exceeding 200 words, to help the reader decide if the information is for him or her.

2) **Introduction.** A short statement giving relevant background, purpose, and scope to help orient the reader. Do not duplicate the abstract.

3) **Experimental Procedure, Materials, Equipment.**

4) **Results, Discussion.** The facts or data obtained and their evaluation.

5) **Conclusion.** An evaluation and interpretation of your results. Most often, this is what the readers remember.

6) Acknowledgment, References and Appendix.

Keep in mind that proper use of terms, abbreviations, and symbols are important considerations in processing a manuscript for publication. For welding terminology, the *Welding Journal* adheres to AWS A3.0:2001, *Standard Welding Terms and Definitions*.

Papers submitted for consideration in the *Welding Journal* Research Supplement are required to undergo Peer Review before acceptance for publication. Submit an original and one copy (double-spaced, with 1-in. margins on 8 1/2 x 11-in. or A4 paper) of the manuscript. A manuscript submission form should accompany the manuscript.

Tables and figures should be separate from the manuscript copy and only high-quality figures will be published. Figures should be original line art or glossy photos. Special instructions are required if figures are submitted by electronic means. To receive complete instructions and the manuscript submission form, please contact the Peer Review Coordinator, Erin Adams, at (305) 443-9353, ext. 275; FAX 305-443-7404; or write to the American Welding Society, 550 NW LeJeune Rd., Miami, FL 33126.

Welding Journal 2009 Editorial Calendar

Editorial Profile

For those engaged in welding-related activities, *Welding Journal* provides current news, features, research reports, practical data, and advertisements from industry leaders around the world. Also featured are welding-related metalworking activities such as design, testing and inspection, maintenance and repair, and training.

		Closing Dates	
		Editorial	Advertising
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		<i>Bonus Distribution:</i> <i>Essen Welding and Cutting Fair</i>	
September	• Understanding Weld Cracking • Welding in the Shipbuilding Industry • Bonus: The American Welder	July 24	Aug. 3
October	• Brazing and Soldering Today • A Look at Aluminum Welding	Aug. 21	Sept. 2
November	• FABTECH International & AWS Welding Show Preview	Sept. 21	Oct. 1
		<i>Bonus Distribution:</i> <i>FABTECH International & AWS Welding Show</i>	
December	• Resistance Welding Developments • Selecting Personal Protective Equipment	Oct. 22	Nov. 2



SUPPLEMENT TO THE WELDING JOURNAL, JULY 2009
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Error Analysis of a Three-Dimensional GTA Weld Pool Surface Measurement System

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BY H. SONG AND Y. M. ZHANG

ABSTRACT

Measurement of weld pool surface is an important research area in the welding community. In recent years, many vision-based approaches have been proposed that have achieved certain successes in this area. However, the accuracy of the measurement results in these systems deserves further consideration since the shape information of small weld pool surface may be used to validate welding models and control the process. In this paper, specific error analysis is given for our early proposed three-dimensional gas tungsten arc (GTA) weld pool surface measurement system, which utilizes the specular reflection characteristic of pool surface to do the measurement. First, all the measurement procedures related to the system error were introduced. Then the included error sources in each procedure were analyzed. Last, experiments and simulations were conducted to estimate measurement system error and other errors quantitatively. Through error analysis, the accuracy of the proposed measurement system was validated and the main error source was identified. This work is not only useful to improve the accuracy of our measurement method, but also instructive for error analysis of the others.

Introduction

The welding process has been widely applied in many manufacturing industries.

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Since welding is a labor-intensive and skill-required operation, automation of the process becomes an attractive way to improve its productivity and quality. Although current welding robots can provide consistent motion, they lack the intelligence that skilled human welders possess to achieve good weld quality by observing the weld pool (surface). Moreover, measurement of the weld pool surface can provide critical experimental data for weld pool modeling research. Hence, precise measurement of the weld pool surface becomes a fundamental requirement for both automated welding machines and welding researchers. In recent years, a few techniques have been applied to sense the weld pool, such as machine vision, X-ray radiation, ultrasonic and acoustic emission, etc. (Refs. 1–4). Among the existing methods, vision-based sensors have been studied the most extensively. In these systems, vision-based sensors are used to acquire images of the weld pool surface, and image processing is followed to extract weld pool surface size/shape information so that control algorithms can use it as a feedback to adjust welding processes (Refs. 5–7).

One early experiment based on direct view of the weld pool has been done in the Welding Research Laboratory at the University of Kentucky by using a specially designed commercial camera whose high-speed shutter was synchronized with

a short duration pulsed illumination laser (Ref. 5). This camera allowed the bright arc light to be eliminated from the image by the intense laser light, and the two-dimensional (2-D) boundary of the weld pool was clearly imaged, as shown in Fig. 1A. Obviously, the accuracy of this 2-D measurement system depends on the proposed 2-D weld pool model and the image processing result (Ref. 5). To use this system in three-dimensional (3-D) weld pool surface imaging, the illumination laser is projected through a frosted glass to form multiple strips. An image with 3-D information can thus be acquired, as shown in Fig. 1B (Ref. 6). Due to the difficulty of precise system positioning, the system is only used for 3-D observation not 3-D measurement. The camera used in the above approaches is extremely expensive and the frame rate can only reach 30 frames per second due to the use of the high-power pulsed illumination laser.

In another system, a structured light technique has been applied to acquire the profile of the weld pool surface by Saeed (Ref. 4). In his system, a laser line is projected onto the center of the weld pool surface, and it is observed by a compact camera system fitted with a band-pass filter. One example of the captured images is shown in Fig. 1C. The 3-D shape of a weld pool profile can be seen. However, the interference of a strong weld arc degrades the quality of the image. The error in this measurement system is in an acceptable range (Ref. 4). In a separate effort, Mnich and his colleagues used a stereovision method to determine the three-dimensional shape of the weld pool (Ref. 7). The main error in this system comes from the correspondence process. Another approach used a similar principle but introduced the biprism technique to reduce the number of needed cameras from two to one (Ref. 8). The accuracy of this system as mentioned by the authors is reasonable. In another sensing system developed by

KEYWORDS

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3-D Reconstruction
Error Analysis
Gas Tungsten Arc Welding
GTAW

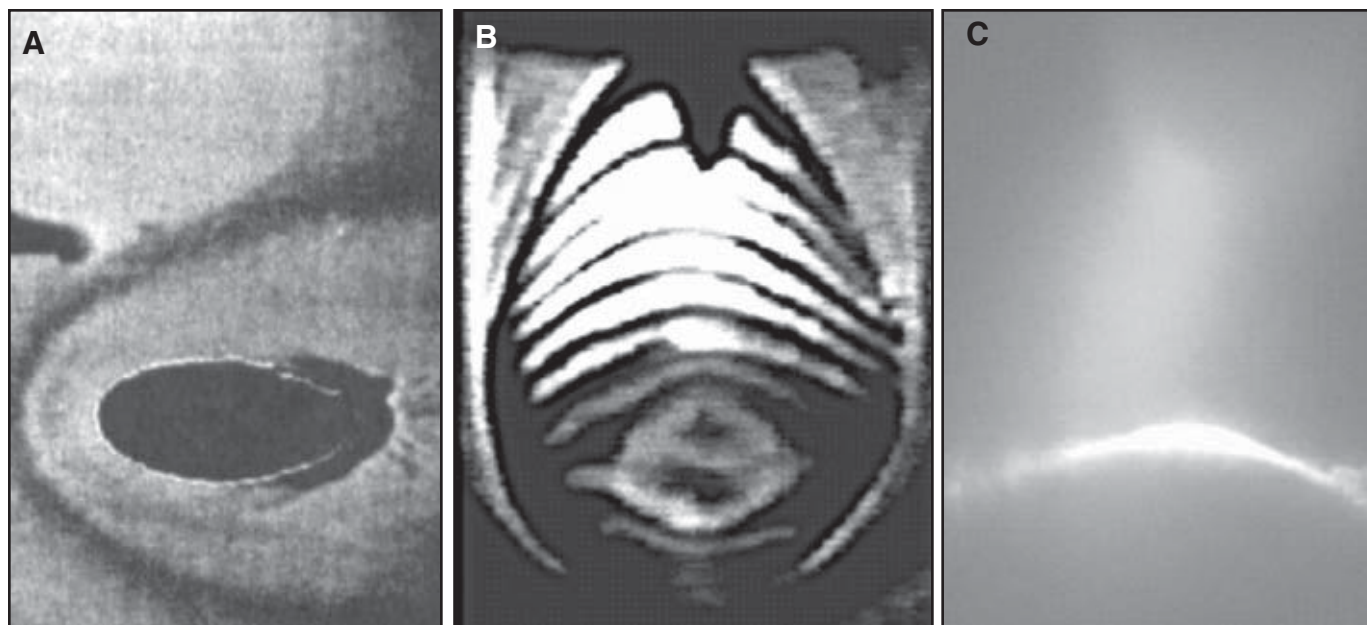


Fig. 1 — Captured images for weld pool surface measurement. A — 2-D shape (Ref. 5); B — 3-D shape (Ref. 6); C — depth/profile extraction (Ref. 4).

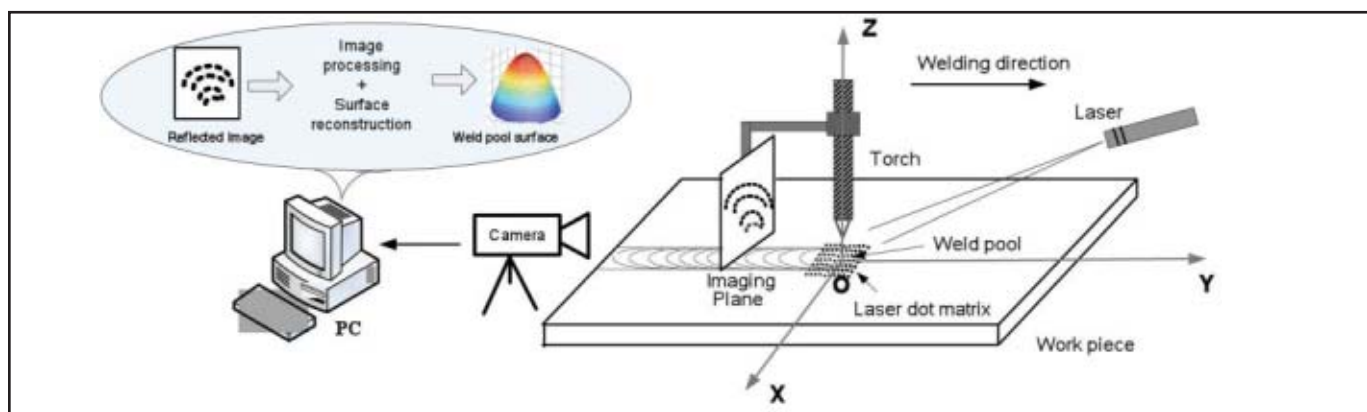


Fig. 2 — Diagram of the proposed measurement system.

Zhang et al. (Ref. 9), the 3-D shape of the weld pool is reconstructed from a 2-D image of the pulsed gas metal arc welding (GMAW-P) process based on the proposed mathematic model. The assumed model may affect the accuracy of the measurement. As another indirect method, the shape-from-shading (SFS) technique was introduced to reconstruct the 3-D weld pool surface by Zhao (Ref. 10). Shape-from-shading is a technique of recovering 3-D information from the variation of shading on the image. Li and Du, respectively, have done further research in this area and greatly improved the methods (Refs. 11, 12). Their approaches all performed good results. However, there are still a lot of difficulties in using the SFS technique, such as the interference of strong arc light. As can be seen, while all these methods have achieved certain successes, more accurate and cost-effective methods are still needed.

In our previous work, a different ap-

proach was proposed to observe the 3-D gas tungsten arc (GTA) weld pool surface (Refs. 13–16). Because of the simplicity (simple system structure and procedures), practicality (practical components, such as 20-mW low-power laser diode), and efficiency (high-contrast and simple acquired images) of the proposed method, it is more suitable for manufacturing process. Furthermore, the system can be more compact if the imaging system is replaced by an image sensor chip with a band-pass filter (Ref. 13). The accuracy of the reconstruction results is discussed qualitatively, but not quantitatively.

In this paper, an extensive error analysis is conducted for the proposed 3-D measurement system. First, the procedures in the system and the related error sources are introduced. Then these errors are classified and the measurability of the errors is discussed. Following that discussion, the overall measurement system error and the other kinds of errors are further investigated ei-

ther by experiments or by simulations. At last, the findings are addressed.

Review of Measurement System

System Structure

It can be seen in some previous studies (Refs. 4, 5) that specular reflection takes place on the molten weld pool surface when laser light is projected onto it. In order to take advantage of the pool surface's reflection property, a new 3-D GTA weld pool surface measurement system is proposed (Refs. 13–16). Its diagram is shown in Fig. 2. In this system, a dot-matrix structured laser pattern is projected onto the weld pool surface at a certain angle, and an imaging plane is placed on the other side to intercept its reflection from the pool surface. Meanwhile, a high-speed camera fitted with a band-pass filter (centered at laser wavelength) is used to capture the reflected images on the imaging plane. The captured

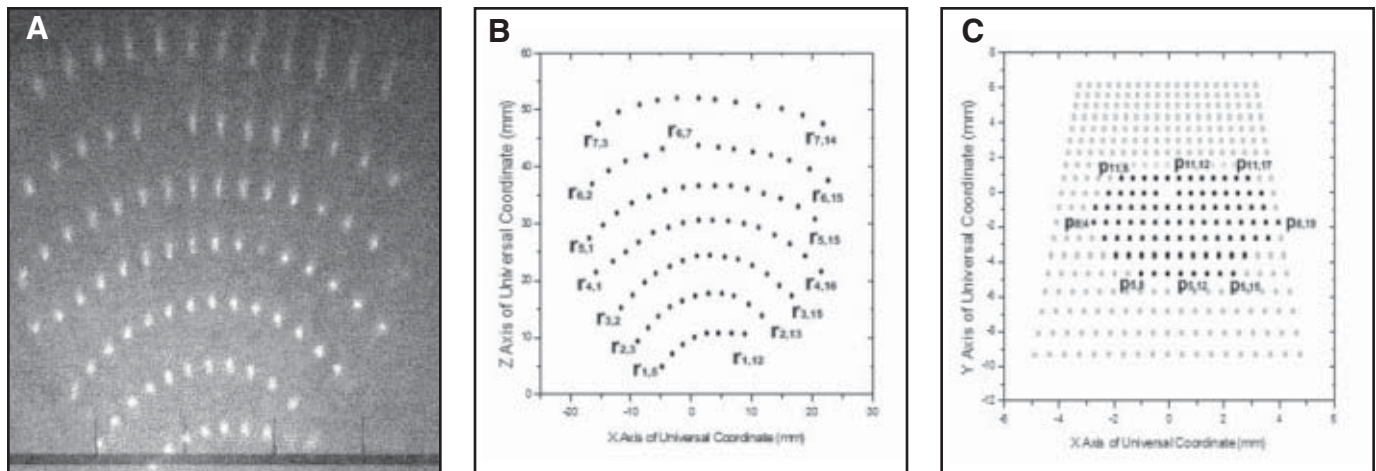


Fig. 3 — Reflected image processing results. A — Acquired reflected image; B — extracted reflected dots $r_{i,j}$ on imaging plane (row number i , column number j) (Ref. 16); C — corresponding projected dots $p_{i,j}$ on workpiece (row number i , column number j) (Ref. 16).

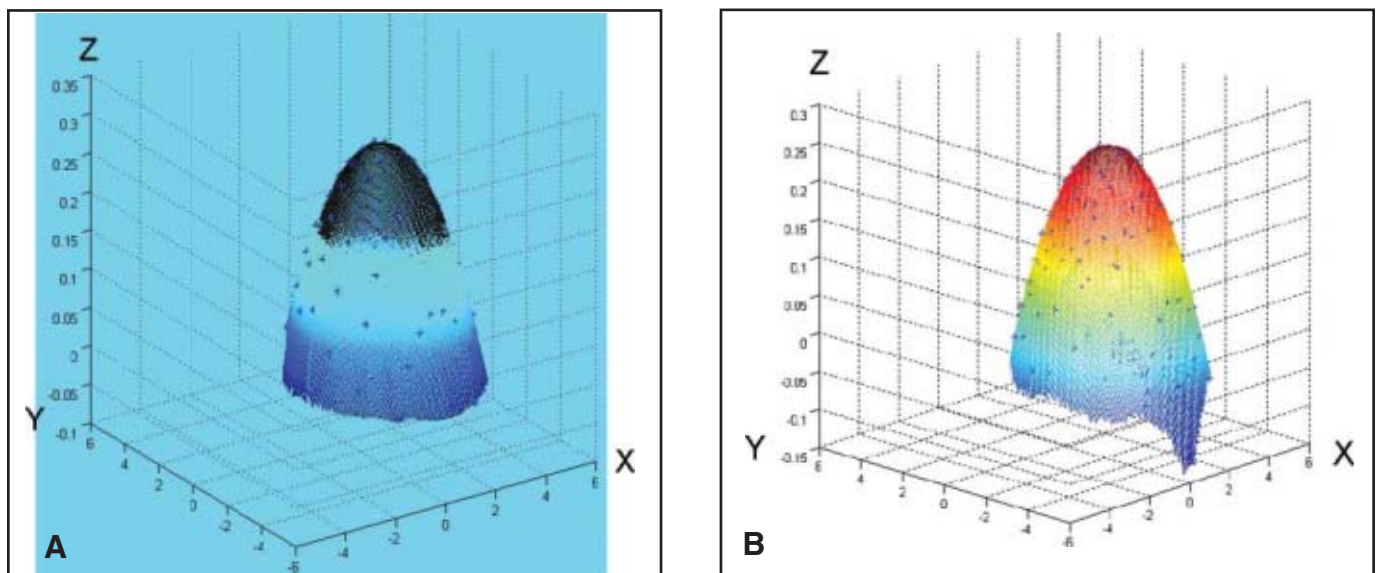


Fig. 4 — Results of different reconstruction schemes (Ref. 16). A — IRS; B — ERS.

images are then processed using developed image processing algorithms and surface reconstruction schemes. Thus 3-D shape of weld pool surface can be reconstructed. In the following, the design and measurement steps along with the introduced errors are briefly introduced and more detailed descriptions can be found in our early work (Refs. 13–16).

Component Selection

Laser (Pattern)

Through investigation, a commercially available 685-nm low-power continuous laser diode (20-mW StockerYale's Lasiris™ SNF) and a diffractive lens with 19×19 dot-matrix structured light pattern were selected (Ref. 14). Theoretically, the higher power and the denser pattern can produce higher contrast in the reflected image and

provide more accurate information for weld pool surface measurement.

Imaging Plane

In the designed system, an imaging plane is used to intercept the reflected laser pattern for image acquisition. To ensure the visibility of the reflected pattern, a piece of 4×4 in. thin glass attached with a sheet of paper was used as the imaging plane. The glass can help resist the high temperature of the arc, but at the same time it may change the route of the reflected lights.

Camera

Considering the dynamic characteristic of the weld pool, an OLYMPUS i-SPEED monochrome camera is used. To minimize the influence of the arc, the camera is fitted with a band-pass filter with 20-nm band-

width centered at a wavelength of 685 nm. In the experiment, frame rate, aperture, and shutter speed are some critical parameters to impact the quality of acquired reflected images, which may ultimately affect the accuracy of the measurement result.

System Configuration

In system configuration stage, some system parameters should be considered carefully. In addition to welding process-related parameters, such as welding current and speed, some important system position parameters are shown below.

Laser Position and Projection Angle

The position and angle of the laser diode determine the position/size of the projected pattern and the directions of incident lights. For the 19×19 dot-ma-

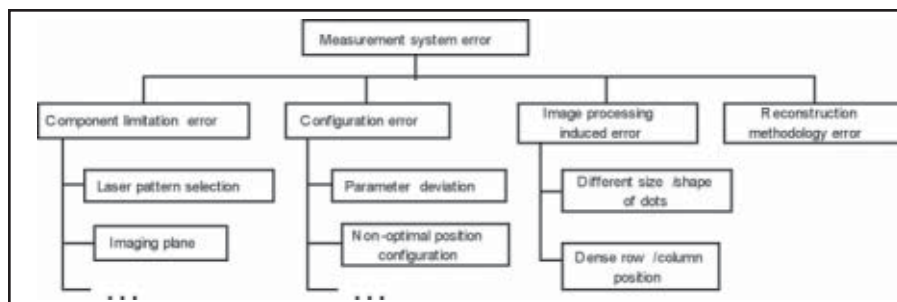


Fig. 5 — Classification of error sources.

trix pattern, the interbeam angle (0.77 deg) is used to present the angle between two adjacent projection rays (Ref. 16). In the system, the projected dot-matrix pattern on the workpiece should be big enough to cover the whole possible weld pool area (about 8×10 mm). The distance between the dots should be very small (less than 0.5 mm) in order to acquire detailed shape information.

The laser projection angle is defined as the angle between the center incident ray and workpiece. This parameter may affect the reflection of the laser lights. For example, for a slightly convex pool surface, if the angle is too large, the reflected lights may be blocked by the torch; if the angle is too small, some of the reflected lights will not be projected onto the imaging plane. Based on the experimental experiences, it is found that around 30 deg is proper for the laser projection angle.

Imaging Plane Position

The distance between the imaging plane and the torch (Z axis) directly impacts the size of reflected laser pattern and the arc intensity in the image. Experiments show the range of 45~60 mm is reasonable for the distance at a certain welding current range (65~75 A).

Image Processing

Figure 3A shows one of the acquired reflected images. As can be seen, only a part of projected dots in the 19×19 dot-matrix is reflected from the pool surface, and they are distorted as some convex curves. In the experiment, the projection angle of the laser diode is 31 deg and the distance between the laser diode and the origin of coordinate system (Fig. 2) is 31.5 mm. The distance between torch and imaging plane is 50 mm. The welding current is 75 A, and welding speed is 3 mm/s.

A point extracting algorithm and matching algorithm were developed to process the images (Ref. 14). First, the reflected points are extracted by using some image processing techniques, such

as block threshold segmentation method, median filter, and morphological operations (Refs. 17, 18). Due to the dispersion of laser light and interference of arc light, the shapes of dots are distorted, which may make their positions imprecise. Based on the positions of reflected dots, some image features can then be determined (Ref. 14), such as row and column positions in Fig. 3B (Ref. 16). To investigate the possible correspondence relationship between projected and reflected dots, correspondence simulation was conducted (Ref. 14). The corresponding projected dots under sequential relationship are shown in Fig. 3C (Ref. 16). The correspondence relationship investigated by simulation simplifies the processing, but unavoidably introduces some errors.

Surface Reconstruction

Based on the acquired information, the next step was to reconstruct the three-dimensional weld pool surface. To resolve this issue, two schemes, interpolation and extrapolation reconstruction schemes (IRS and ERS), have been proposed to find an optimally estimated three-dimensional surface (Ref. 16). In the proposed schemes, first, a 3-D pool surface is estimated using either interpolation or extrapolation method in an iterative process, and then a 2-D boundary model is derived to find the surface boundary. Figure 4 shows the 3-D weld pool surfaces reconstructed by IRS and ERS for the reflected image in Fig. 3A. The result of ERS is more reasonable since the rear part of weld pool is lower than the other parts, which meets the result of direct observation (Ref. 16).

Error Analysis

Figure 5 shows the classification of the possible error sources according to four design and measurement procedures in the system. Here measurement system error refers to the overall error of the reconstructed 3-D weld pool surface caused by the proposed system.

Component limitation error refers to

the error caused by the selected components. It is measured as the achievable minimal error by using the selected components. As mentioned before, the density of the laser pattern is one of the critical influence factors for measurement accuracy. Due to the availability, a 19×19 dot-matrix pattern is selected rather than a denser pattern. Some other nonideal components, such as self-designed imaging plane, may also contribute to component limitation error. This type of errors can be reduced by increasing the precision of the used components.

Configuration error is introduced because of the imprecise or improper parameters used in the system. Some deviations must exist between the measured nominal values and the actual values of the system parameters. Thus, parameter deviation is an error source. Possible ways to reduce this error include improving the system calibration method and averaging the values from multiple measurements. Nonoptimal system position parameters may also cause errors. For instance, if the position or projection angle of the laser diode is not properly configured, the laser pattern fails to cover the whole weld pool, which may ultimately make the reconstructed surface inaccurate.

In the step of image processing, the reflected dots are extracted from the background based on the intensity difference. As can be seen in Fig. 3A, the shape and size of reflected dots vary. Thus, it is hard to extract the positions of the reflected dots precisely. Furthermore, since the reflected dot-matrix pattern is distorted with densely distributed dots, sometimes it is very difficult to decide the row and column positions of the reflected dots. Hence, mismatch of the projected and reflected dot may also happen. These are the main sources of the “image processing induced error.”

In the surface reconstruction process, the reflection point on the pool surface cannot be precisely decided based on the reflection law since only incident ray and its one reflected dot are known. Thus, in the reconstruction schemes an iteration process is proposed to find the optimal estimation for the weld pool surface. The error introduced by the reconstruction schemes is defined as “reconstruction methodology error.”

It can be seen that there are many error sources in the measurement system. Among them, some error sources are random and unpredictable, such as the parameter deviation and the imaging processing induced error, while some errors are measurable and can be analyzed quantitatively through either experiments or simulations.

Measurement System Error

Measurement system error is the over-

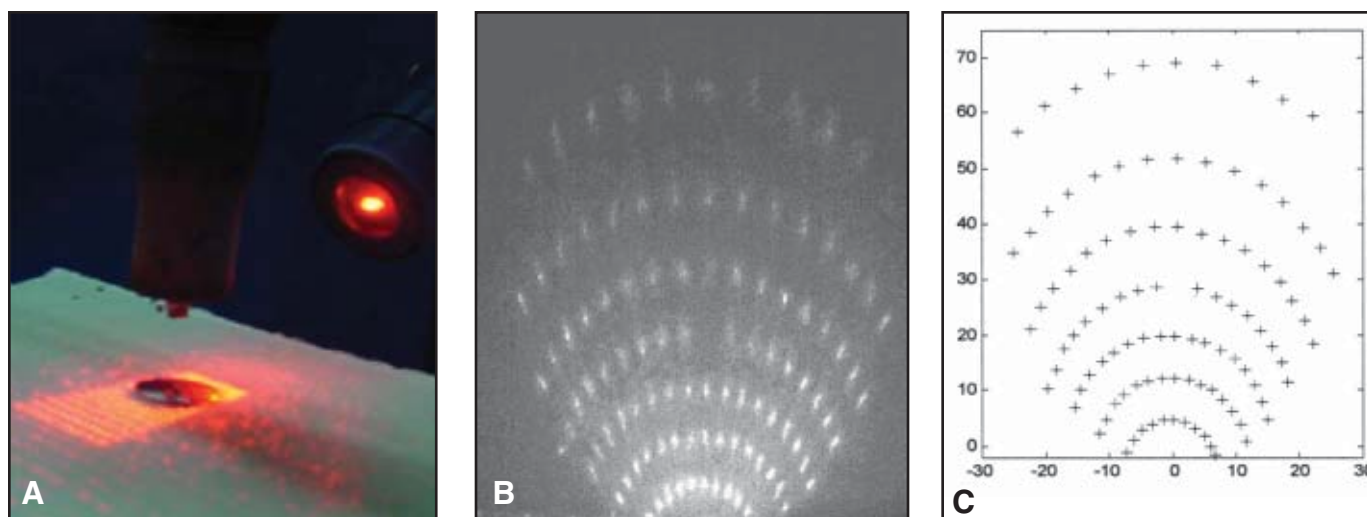


Fig. 6 — Experiment of measurement system error. A — Experiment design; B — captured image; C — extracted reflected dots on imaging plane.

all error of the measured 3-D weld pool surface. During the welding process, it is impossible to obtain the actual shape of the weld pool surface to compare with the measurement result. Thus, in order to estimate the overall measurement system error quantitatively, a thumb tack is selected to replace the weld pool for the experiment because the size and shape of its cap are similar to the weld pool, and its surface can reflect the laser light well. Figure 6A and B show the designed system and the acquired reflected image. In the experiment, the projection angle of the laser diode is 30.6 deg, and the distance between laser diode and origin of coordinate system is 46.4 mm. The distance between imaging plane and the torch is 40.7 mm. Figure 6C shows the result of image processing. The surfaces rebuilt by IRS and ERS are shown in Fig. 7. In the experiment, a circle model is used since the boundary shape of the thumb tack is known in advance. It can be seen that the shape of reconstructed surfaces fit the thumb tack well.

The reconstruction results from using the proposed 3-D measurement system can thus be compared with the thumb tack. Here the difference (error) in three dimensions can be calculated as the estimated measurement system error. Here the measurement error (E_{me}) can be defined as Equation 1.

$$E_{me} = \frac{|L_c - L_a|}{L_a} \cdot 100\% \quad (1)$$

where L_c presents the calculated value (of diameter or height) and L_a presents the actual value (of diameter or height). In the experiment, the diameter of the thumb tack is 9.75 mm, and its height is 0.91 mm. The diameters of the reconstructed pool boundaries in Fig. 7 are both 9.9 mm with

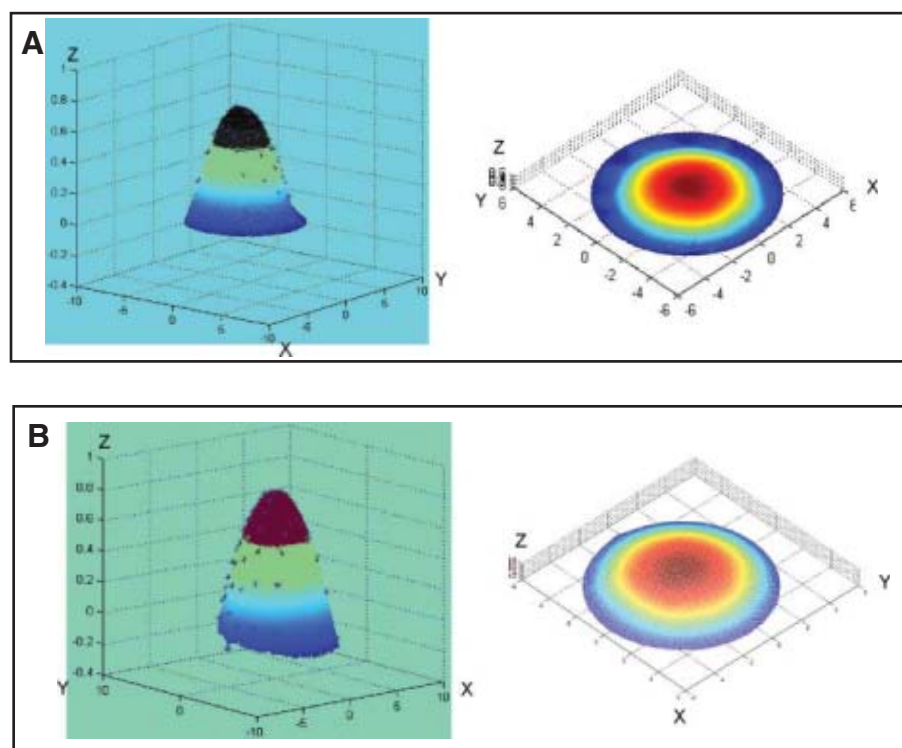


Fig. 7 — Reconstructed surfaces of the thumb tack. A — Result of IRS (view with magnified Z-axis and view with equal axes); B — result of ERS (view with magnified Z-axis and view with equal axes).

1.49% measurement system error. For IRS, the height of the pool surface is 0.75 mm with 17.8% measurement system error. For ERS, the calculated height of the surface (above $Z=0$ plane) is 0.83 mm with 9.1% measurement system error. It is obvious that the result of ERS is better than that of IRS. Since it is a measurement system for a small object, the achieved small measurement errors are acceptable.

Other Separated Errors

In this section, simulations are conducted to study some separated errors in the measurement system. In the error numerical simulation, first, the dot-matrix laser pattern is assumed to be projected onto some known surfaces. Thus, the corresponding reflected image on the imaging plane can be computed. Then the

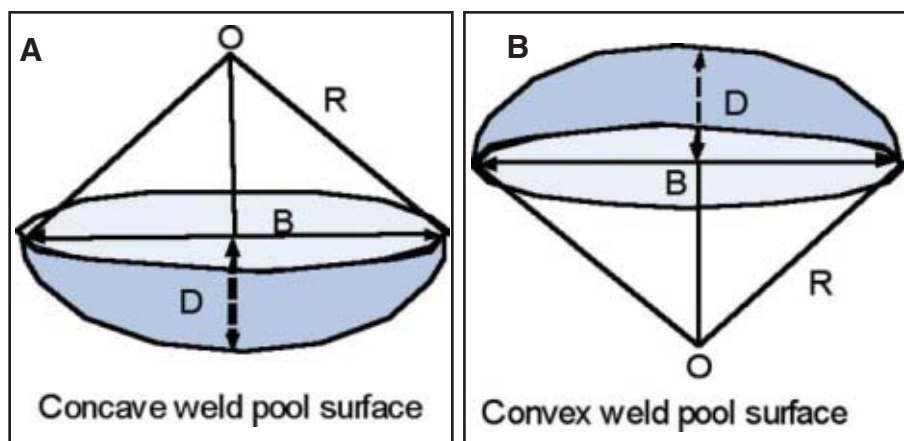


Fig. 8 — Two kinds of test surfaces. A — Concave simulation surface; B — convex simulation surface.

obtained reflected image is regarded as the captured images in the practical experiment and used to rebuild the pool surface. At last, the reconstructed result is compared with the known surface, thus the measurement error can be calculated.

Figure 8 shows the simplified concave and convex weld pool surfaces for simulation. The surfaces are a part of a sphere. In the figures, B refers to the diameter of the surface boundary (circle) and D is its depth. For the tested surfaces, the diameter B varies from 5 to 8 mm and the depth D changes from B/20 to B/10. These sizes are selected according to the practical dimensions of GTA weld pool surfaces.

Here three important errors are evaluated. They are configuration error, component limitation error, and reconstruction methodology error. Their corresponding main sources are nonoptimal configuration, nonideal laser pattern selection and iterative surface reconstruction scheme, respectively. Since these error sources are included in the sequential steps of measurement, these errors cannot be separated completely for error, measurement. Since all the errors should be calculated by using the same standard, we eliminate the error sources one by one and calculate the ultimate measurement errors of the reconstruction results in the designed three simulations. For simplicity reasons, the calculated measure errors are still called configuration error, component limitation error, and reconstruction methodology error. It will be seen later that these values are still reasonable estimates although the latter error(s) may be included in the former one.

Configuration Error

The configuration error is mainly caused by the nonoptimal displacement of the laser diode. In the simulation, only one case of nonoptimal displacement is stud-

ied as a representative to evaluate configuration error and the simulation parameters used are the same as the ones in the experiment discussed previously.

Dimensional Parameter Error

In order to describe the differences between the reconstructed and actual 3-D weld pool surfaces, two dimensional error measurement parameters are introduced: configuration error of depth (E_{ced}) and configuration error of boundary (E_{ceb}). They are defined as Equations 2 and 3, which are similar to the definition of measurement error.

$$E_{ced} = \frac{|D_c - D_a|}{D_a} \cdot 100\% \quad (2)$$

where D_c is the computed depth of the reconstructed surface and D_a is the actual depth of the simulated surface.

$$E_{ceb} = \frac{|B_c - B_a|}{B_a} \cdot 100\% \quad (3)$$

where B_c is the computed diameter of surface boundary, and B_a is the actual diameter of the simulated surface.

Figure 9 shows the configuration errors for different convex and concave surfaces by using the extrapolation reconstruction scheme (ERS). In the simulation, the boundary model has also been changed to a circle. As can be seen, E_{ceb} is very small for both convex and concave surfaces, and it is in a range of 0.03–2.51%, which shows the boundary model fits the tested surfaces well. But E_{ced} is relatively larger. For the convex surfaces, it varies from 0.78 to 10.85%. For the concave surfaces, it varies from 0.1 to 26.9%. The average of E_{ced} is about 8%.

It can be concluded that the error performance even under the same system configuration may vary greatly due to the different shapes/sizes of weld pool surfaces. For the large variation of E_{ced} , the possible explanation is in some cases laser

dots are not projected onto the highest/lowest position of the convex/concave surfaces because of the limited density of the projected dot matrix (19×19). Thus, the height/depth of the surface cannot be reconstructed correctly by the reconstruction scheme. This phenomenon shows the optimal system configuration is only associated with a specific shape of weld pool surface, not all the situations.

Reflection Points Error

Despite the diameter and height/depth of the surface, the error caused by configuration can be further investigated by evaluating the differences of positions between computed and actual reflection point on the simulated weld pool surface. Since the tested surface is known, the difference can be achieved as average reflection point error E_{are} by using Equation 4.

$$E_{are} = \sum_{i,j} D_{i,j} / n, \dots, (i, j) \in S \quad (4)$$

where S refers to the simulated surface and n represents the number of the reflection points on the surface. $D_{i,j}$ represents the distance between the computed reflection point $p'_{i,j}$ on the reconstructed surface and the actual reflection point $p_{i,j}$ on the tested surface. In the simulation, the average reflection error (E_{are}) by using ERS is in the range of (0, 0.25) mm. The small value of difference has verified the accuracy of the proposed reconstruction schemes.

It should be noted that the configuration error computed in Fig. 9 includes the component limitation error and reconstruction methodology error. Fortunately, as will be seen from the discussion below, these errors are very small. Hence, the above computation does give us a reasonable estimation of the configuration error.

Component Limitation Error

In order to minimize the impact of configuration parameters and investigate the component limitation error caused by 19×19 dot-matrix pattern, simulations with system position parameters in a reasonable range were conducted. The laser projection angle varied from 25 to 35 deg, and its distance to the origin of the coordinate system changed from 25 to 35 mm. Thus, the component limitation error can be estimated as the minimal error in the conducted simulations when the nominal optimal configuration is achieved.

Figure 10 shows the component limitation errors by applying ERS to different convex and concave surfaces. Here, two error parameters, called component limitation error of boundary (E_{leb}) and depth (E_{led}), are defined as similar to Equations 2 and 3. It can be seen in Fig. 10 the component limitation errors are much less

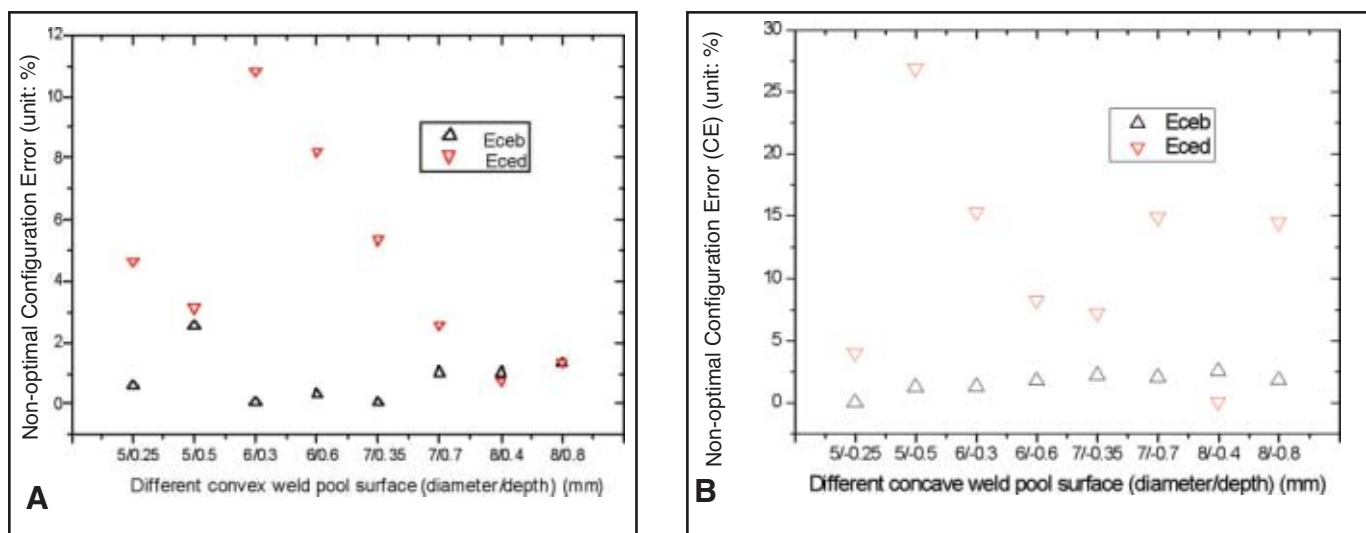


Fig. 9 — Configuration errors measured by using different surfaces. A — Convex surfaces; B — concave surfaces.

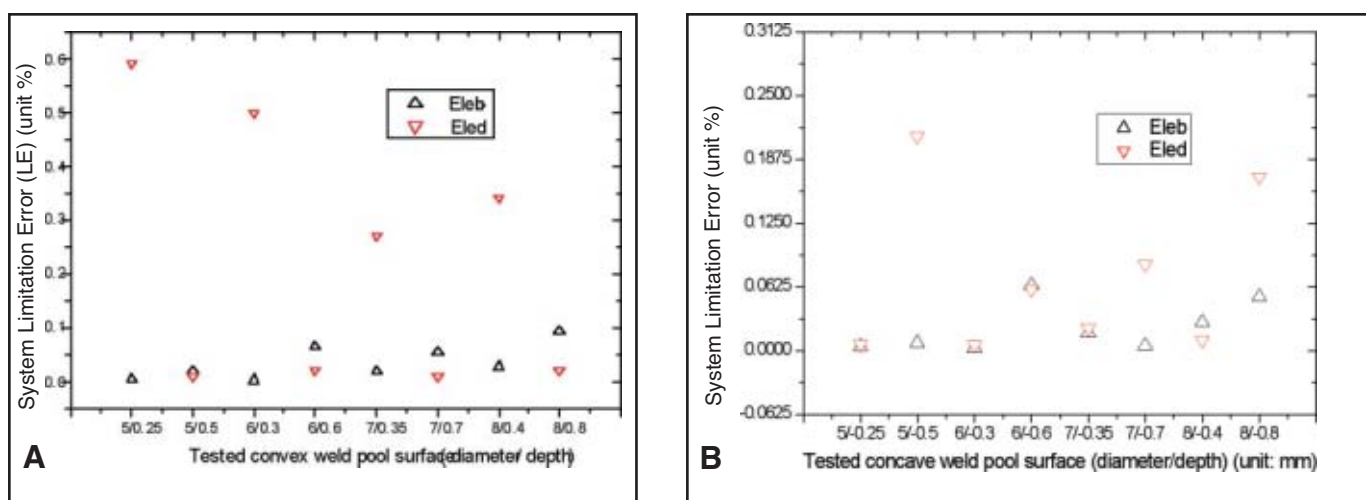


Fig. 10 — Component limitation error measured by using different surfaces. A — Convex surfaces; B — concave surfaces.

than the configuration errors in Fig. 9. In particular, the maximal boundary error is reduced from 2.8 to 0.1%, and the maximal depth error is reduced from 26.9 to 0.6%. Hence, the configuration error appears to be the major contributor to the overall measurement system error. Furthermore, the computed average reflection error (E_{are}) is less than 0.01 mm, which is much smaller than that in the configuration error simulation.

It is apparent that the computed system limitation error also includes the reconstruction methodology error. Hence, an investigation is needed to estimate the error caused by the reconstruction method.

Reconstruction Methodology Error

In the proposed measurement system, the reconstruction scheme itself may also introduce error because of some assump-

tions and approximations taken in it. Based on the simulation with various position configurations shown previously, a 39×39 dot-matrix pattern is used instead of a 19×19 dot-matrix pattern in order to evaluate the reconstruction methodology error with less impact of selected laser pattern. Although its scale is not approaching infinite by infinite, it is still reasonable to use it to estimate the error performance without the component limitation error. In the simulation, the interbeam angle of the dot-matrix laser pattern is decreased to 0.385 deg (half of its original value). Thus, the projected dots become denser and the projection area nearly stays unchanged.

Figure 11 shows the computed reconstruction methodology errors. Here reconstruction methodology error of boundary (E_{reb}) and depth (E_{red}) are also defined similar to Equations 2 and 3. Compared with the result of using 19×19 dot-matrix pat-

tern, the calculated reconstruction methodology error by using 39×39 pattern is much less, and the values of E_{reb} and E_{red} are approaching to zero (maximum 0.17%) for both convex and concave surfaces. If given infinite dense projected dot-matrix, the reconstruction methodology error should not even exist. Of course, the small value of result is also related to the selected highly regulated simulation surfaces. The calculated average reflection error (E_{are}) is less than 0.005 mm, which is much smaller than that in the component limitation error simulation. It is evident that the insignificant reconstruction methodology error has proved the accuracy of the proposed reconstruction scheme.

Conclusion

Measurement of three-dimensional weld pool surface is an important and ur-

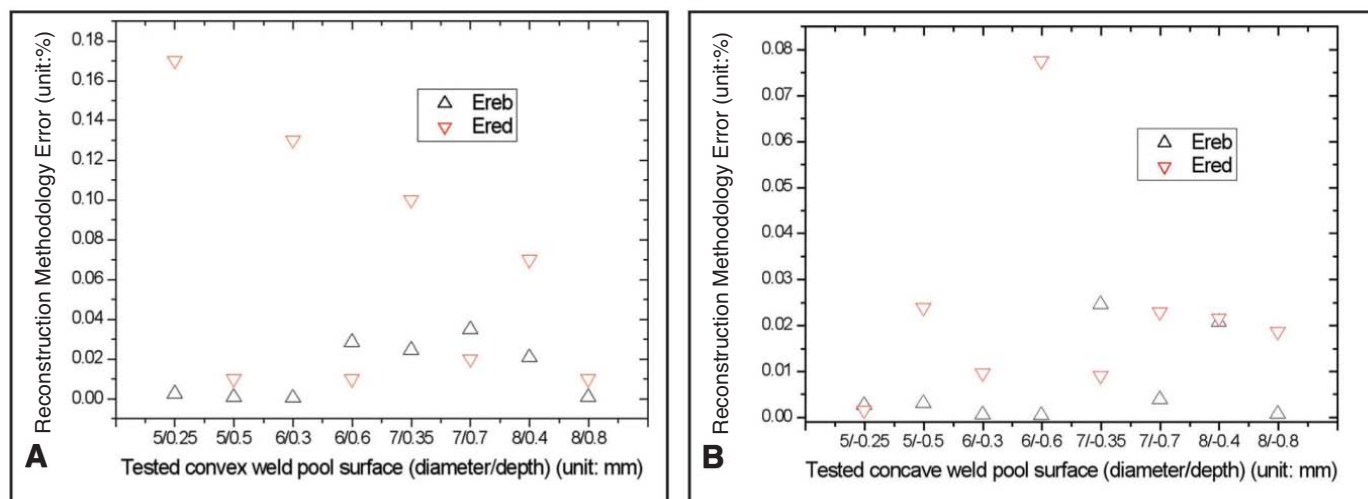


Fig. 11 — Reconstruction methodology errors measured by using different surfaces. A — Convex surfaces; B — concave surfaces.

gent task in the welding community. In our early work, a new 3-D measurement system has been proposed. Since the measured object is small and dynamic under harsh welding environment, an extensive error analysis of the measurement system is necessary.

In this paper, experiments and simulations have been conducted to evaluate various errors in the proposed 3-D measurement system. In the system, error sources have been divided into four types according to the measurement procedures. The authors found the following:

- The configuration error is the major error source that contributed to the overall measurement system error, whose average value is about 8%. Other studied errors, including the component limitation error (less than 1%) and surface reconstruction methodology error (less than 0.2%), are relatively insignificant.

- The configuration error is primarily caused by the mismatch of the projected laser pattern in relation to the particular weld pool surface to be measured. When the mismatch is eliminated, the configuration becomes optimal and the error reduces to the component limitation error. Reduction of the mismatch may be a method to improve the measurement accuracy significantly without changing either the components of the measurement system or the surface reconstruction method. In practical experiments, the variance of the weld pool surface makes it difficult to always achieve optimal configuration. Thus increase of the density of the projected laser dot-matrix appears to be a more practical and effective way to reduce both configuration error and component limitation error.

- Through the test for a physical object with known dimensions, the measurement system error was obtained (approximately

10% error by using ERS scheme). The reasonably small measurement error has verified the accuracy of the proposed three-dimensional specular surface measurement system.

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Ultrasonic Metal Welding Process Robustness in Aluminum Automotive Body Construction Applications

Process robustness to four key manufacturing variables — weld orientation, aluminum sheet rolling direction, residual stamping lubricant level, and material age — was established

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ABSTRACT

Ultrasonic metal welding is a promising joining method for aluminum automotive body construction applications. In order to achieve technology implementation readiness, process robustness to weld orientation, aluminum sheet rolling direction, residual stamping lubricant level, and material age must be assessed. Experiments were conducted to characterize variations in weld failure loads and microstructural features resulting from the directional nature of the energy input during ultrasonic welding to ensure that the angle at which components are ultrasonically welded together does not affect weld performance. These experiments were also designed to ascertain whether the orientation of a welding machine with respect to the rolling lines on an AA6111 sheet component or the relative orientation of the rolling directions of two components being joined is critical. A second set of experiments was conducted to determine the effects of surface lubricant level on tensile-shear and T-peel failure loads and fatigue performance for AA6111 and AA5754 sheet. Robustness to surface lubricant level is important because often in North American automotive production facilities, components are not cleaned prior to welding; rather, they are welded with residual stamping lubricant on the surfaces. Finally, because AA6111 naturally ages at room temperature for an extended period of time in the T4 temper, experiments were performed to ascertain the impact of AA6111 material age on ultrasonic weld tensile-shear and T-peel failure loads. For all factors considered in this study, ultrasonic metal welding process robustness was demonstrated.

Introduction

Ultrasonic metal welding is a novel and promising joining technique for automotive body construction applications. It is a solid-state welding process that produces coalescence through the simultaneous application of localized high-frequency vibratory energy and moderate clamping forces. Ultrasonic metal welding requires significantly less energy than competing processes such as resistance spot welding; has variable costs an order of magnitude lower than self-pierce riveting; and is characterized by low heat input, thereby alleviating issues related to part distortion, aluminum alloy property degradation, and part handling safety. In addition, the performance of aluminum ultrasonic spot welds compares favorably with that of other types of joints both under quasi-static and dynamic loading (Ref. 1).

Ultrasonic spot welding systems include wedge-reed, lateral-drive, and torsion configurations. In all of the systems, ultrasonic vibration is generated by one or more transducers, which convert the high-frequency electrical energy generated by the power supply into mechanical vibratory energy of the same frequency. This vibration is transmitted through a sonotrode into the workpieces, with tip vibration in a plane parallel to the plane of the weld interface. In the case of commercially available wedge-reed and lateral-drive systems, tip vibration is linear and in the same direction as transducer movement. In the case of torsion welding systems, a special arrangement of multiple

transducers facilitates a reciprocating torsional motion of the sonotrode. For all of the aforementioned weld configurations, a static force is applied perpendicular to the plane of the weld interface to clamp the workpieces together between the sonotrode tip and the anvil. The frictional action between the workpiece surfaces as they are subjected to ultrasonic vibration and clamping pressure disperses interface oxides and contaminants and brings about metal-to-metal contact and bonding.

Ultrasonic metal welding equipment was developed in the 1940s and 1950s (Ref. 2) and was first patented in the United States in 1960 (Ref. 3). Traditional applications for ultrasonic metal welding include tube sealing, wire bonding, and thin foil joining. Ford Motor Co. and three joint venture partners — Branson Ultrasonics Corp., Edison Welding Institute, and Sonobond Ultrasonics Inc. — have recently concluded a four-year National Institute of Standards (NIST) Advanced Technology Program (ATP) (Ref. 4) to develop ultrasonic metal welding capability for aluminum closure and structural welding applications.

Lightweight materials such as aluminum allow automotive manufacturers to reduce vehicle weight to improve fuel economy and reduce CO₂ emissions. The principal barrier to the increased use of aluminum in automotive body and chassis applications is cost. Both the material cost and the body-in-white manufacturing cost are higher than that of steel. In order to achieve expanded use of aluminum in automotive body construction, lower-cost joining methods are important. Ultrasonic metal welding is one such potential joining method, but requisite to its implementation in automotive body

KEYWORDS

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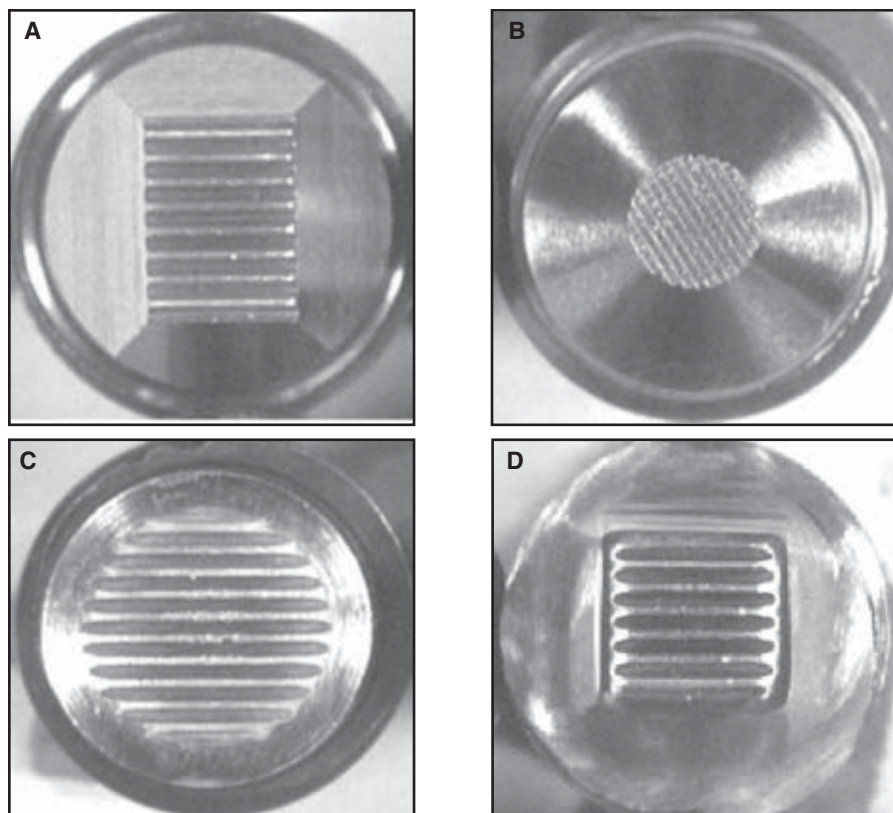


Fig. 1 — Typical sonotrode tip gripping surface patterns: A — Flat row; B — flat axisymmetric; C — spherical row; D — cylindrical row.

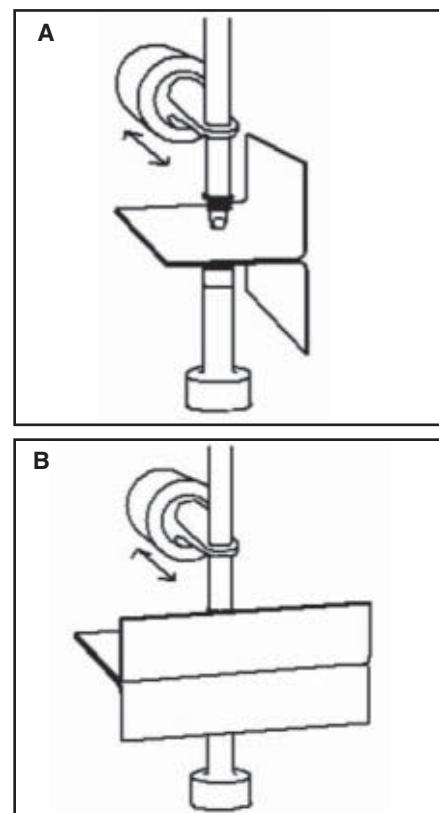


Fig. 3 — Test direction relative to vibration input direction - T-peel samples: A — Perpendicular; B — parallel.



Fig. 2 — Welding setup for weld orientation and sheet rolling direction experiments.

construction applications is demonstration of process robustness to manufacturing variables. In this study, process robustness to four critical issues — weld orientation, aluminum sheet rolling direction, residual stamping lubricant level, and material age — was evaluated.

Robustness to Weld Orientation

Objective

In the case of linear welding systems, i.e., the wedge-reed and lateral-drive configura-

tions, the energy input during ultrasonic welding is linear and in the same direction as transducer movement, so it is directional in nature. Prior work has indicated that this directional energy input might influence ultrasonic metal weld quality, but no studies have specifically addressed this issue. Tsujino et al. (Ref. 5) developed complex vibration longitudinal-torsional ultrasonic welding systems to ensure weld strength independence with respect to the angle between welding tip vibration and specimen loading orientation. Jones et al. (Ref. 6) investigated the fatigue strength of multi-

weld aluminum panels as a function of vibration input direction, having noted a lack of symmetry in the surface marks left by the welding tip and the deformation at the interface. Their findings with regard to fatigue strength as a function of vibration input direction were inconclusive, however.

It was the objective of this study to determine whether welds made with linear ultrasonic metal welding systems were directional in nature or if they were independent of weld orientation. This is critical for ensuring that the angle at which components are ultrasonically welded together does not affect weld performance. In addition, the gripping surface pattern on many ultrasonic metal welding tips is nonaxisymmetric, as is shown in Fig. 1. As such, it was a second objective of this study to determine if tip geometry and gripping surface pattern affect the axial uniformity of weld properties.

Experimental Procedure

All welding was conducted using a Sonobond pedestal welding machine, as shown in Fig. 2. Welds were made on completely overlapping, 178-mm square sheets of 0.9-mm AA6111-T4. Square sheets were chosen such that all weldments presented identical vibratory conditions to the welding machine. All welding was conducted with a locator fixture to ensure consistent specimen orientation and location with respect

to the tip, as shown in Fig. 2. Four types of welding tips were used (shown in Fig. 1) — flat contact area with and without axisymmetric gripping surface patterns, spherical, and cylindrical (i.e., different radius of curvature side to side than front to back). Different welding parameters were selected for each tip type, and all welding was conducted in an energy-controlled mode, with the power supply set to deliver a specified amount of energy but weld duration not inherently constrained.

A D-optimal designed experiment (DOE) was conducted to simultaneously evaluate the impact of weld orientation and aluminum sheet rolling direction (as detailed in the next section) on tensile-shear failure load, T-peel failure load, button size, weld time, and weld microstructure. A total of 288 welds were made — 12 replicates of 24 different combinations of factors. Five of the replicates were for testing in tensile-shear, five for testing in T-peel, and two for microstructural evaluation. For each weld, the voltage and current were measured at the power supply output, on the low-voltage (primary) side of the matching transformer. After welding, samples were bent to prescribed geometries for T-peel and tensile-shear testing, with T-peel and tensile-shear failure loads measured either parallel to or perpendicular to the vibration input direction, as is illustrated schematically in Figs. 3 and 4. Tensile-shear and T-peel testing were conducted using an Instron Model 4505 with a crosshead speed of 10 mm/min, with samples mounted as shown in Fig. 5.

Specimens for microstructural analysis were sectioned either parallel or perpendicular to the direction of vibration input, as shown in Fig. 6, using a medium-speed diamond cutoff wheel. Cross sections were cold mounted using a two-component epoxy resin, polished, etched, and examined with optical microscopy. For each weld cross section, 19 microstructural features were measured, as listed in Table 1 and shown in Fig. 7.

Results

In order to facilitate the consistent presentation of the results of this study with those of the subsequent three studies, results presented here focus on those specific to the flat row tip. DOE analyses indicated that the effect of changing test direction on tensile-shear and T-peel failure loads and button sizes was insignificant. Figure 8 plots mean failure load as a function of test direction (averaged across all other factors), with error bars corresponding to ± 1 standard deviation. Figure 9 displays mean button size as a function of test type and test direction (averaged across all other factors), again with error bars corresponding to ± 1 standard deviation. Note that button area, rather than button diameter, was used as

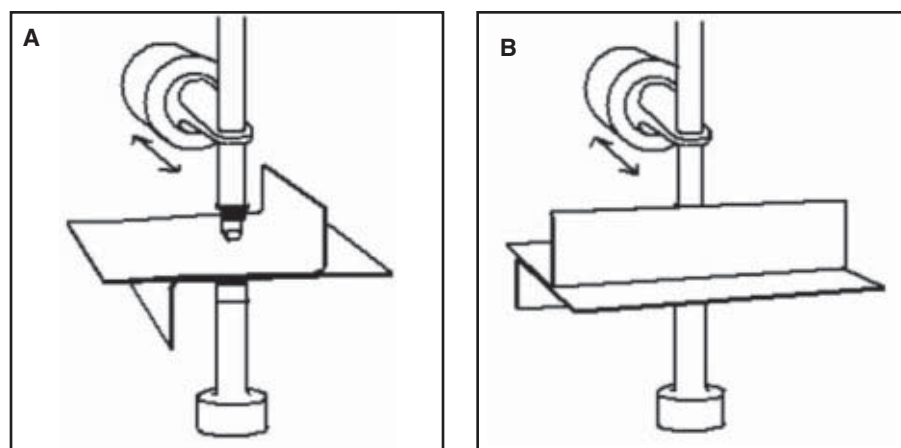


Fig. 4 — Test direction relative to vibration input direction — tensile-shear samples: A — Perpendicular; B — parallel.

the metric for button characterization. This method has been found to more accurately characterize the noncircular buttons that result frequently during ultrasonic metal welding due, in part, to noncircular tip geometries. Each bar in Figs. 8 and 9 represents the average of 15 welds. All eight data sets exhibited normality, and tensile-shear and T-peel failure load and button size data displayed equal variances and equal means at the 95% confidence level, respectively, as a function of test direction. As previously

mentioned, it was therefore concluded that ultrasonic weld quasi-static strength is robust to weld orientation for 0.9-mm AA6111-T4 sheets joined with a flat row tip.

Typical weld zone microstructures for the flat row tip, for sections taken both parallel and perpendicular to the vibration direction, are shown in Fig. 10, with a higher magnification view of the area indicated in blue shown in Fig. 11. It is evident from the full anvil and tip imprints that both coupons were securely gripped during welding. The

Table 1 — Microstructural Feature Designations

Symbol	Microstructural Feature
A1	Side thickness — top sheet thickness adjacent to welded area
A2	Side gap — vertical gap between upper and lower specimens adjacent to welded area
A3	Side angle — angle between upper and lower specimens adjacent to welded area
B1	Indent width — width of welder tip imprint, measured at base of indents
B2	Weld diameter — horizontal distance between the unwelded gaps at the edge of the weld zone
C1	Tip peak-valley — vertical distance between tip peaks and valleys
C2	Tip side-valley — vertical distance between unwelded surface and tip valley imprints
C3	Tip side-peak — vertical distance between unwelded surface and tip peak imprints
D1	Anvil peak-valley — vertical distance between anvil peaks and valleys
D2	Anvil side-valley — vertical distance between unwelded surface and anvil valley imprints
D3	Anvil side-peak — vertical distance between unwelded surface and anvil peak imprints
E1	Weld thickness — average thickness of the welded region of the sample
F1	Weld thickness, tip side — vertical distance between the weld zone centerline and the tip indents
F2	Weld thickness, anvil side — vertical distance between the weld zone centerline and the anvil indents
G1	Wake left — vertical height of the leftmost wake feature
G2	Wake right — vertical height of the rightmost wake feature
G3	Wake 1 — vertical height of the 1st of the 3 most prominent wake features within the body of the weld
G4	Wake 2 — vertical height of the 2nd of the 3 most prominent wake features within the body of the weld
G5	Wake 3 — vertical height of the 3rd of the 3 most prominent wake features within the body of the weld

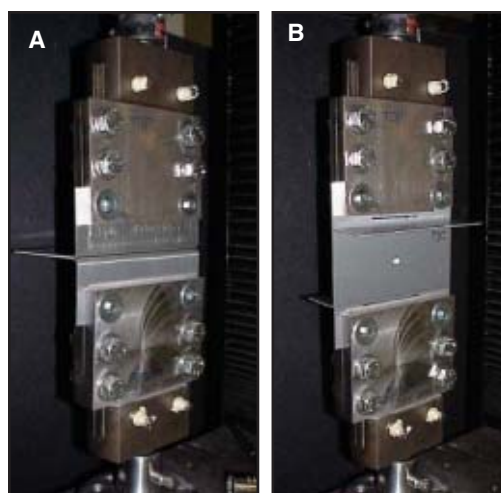


Fig. 5 — Samples mounted for tensile testing: A — T-peel sample; B — tensile-shear sample.

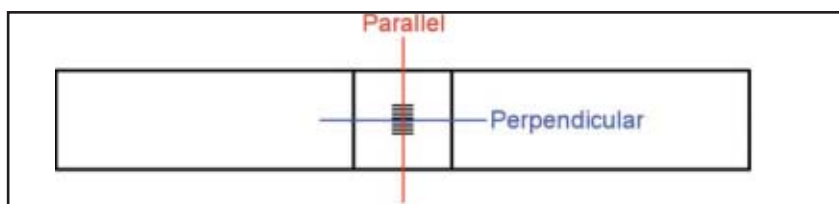


Fig. 6 — Weld section schematic (welds sectioned at weld centerline).

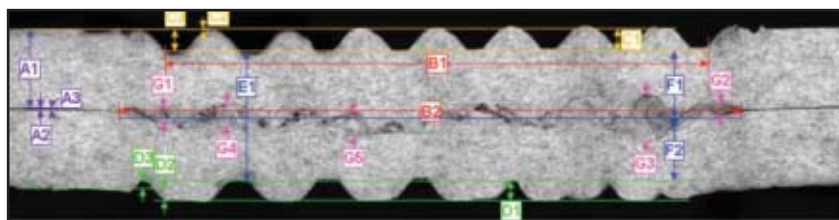


Fig. 7 — Measurement of weldment microstructural features.

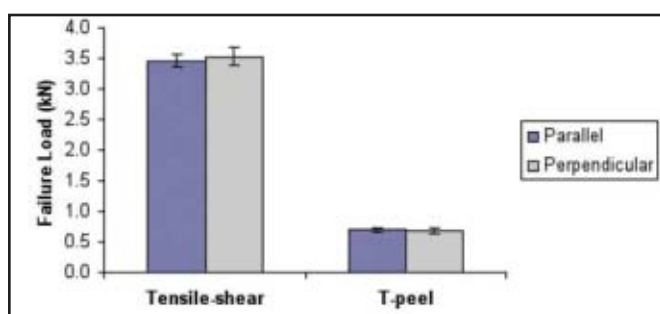


Fig. 8 — Tensile-shear and T-peel weld failure load as a function of test direction.

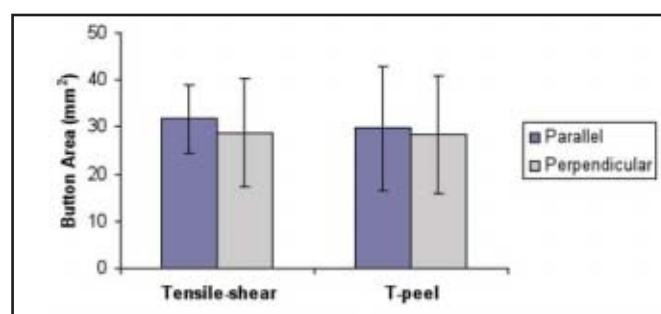


Fig. 9 — Button size as a function of test type and test direction.

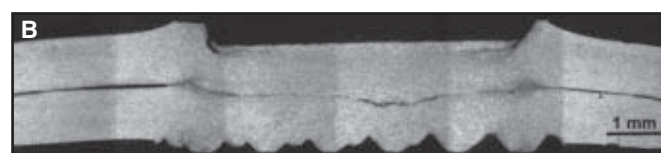


Fig. 10 — Ultrasonic weld microstructure as a function of cut direction: A — Cross section taken parallel to vibration direction; B — cross section taken perpendicular to vibration direction.

interfacial wake features almost completely span the width of the tip contact area. Other than some grain elongation near the tip and anvil contact interfaces and some submicron size grain refinement directly adjacent to the displaced interface, there is no notable difference in grain structure between the welded and unwelded regions of the samples. In the perpendicular weld cross section, more material displacement above the top surface of the coupon is apparent.

As detailed previously, 19 microstructural features were used to characterize ultrasonic weldability as a function of weld orientation and component rolling direction. It should be noted that microstructural measurements are sensitive to cross-sectional cut location; mounting, polishing, and etching procedures; and operator-to-operator variation in feature selection. Nevertheless, numerous conclusions can be

drawn with respect to microstructural feature correlations with weld strength and the responses of microstructural features to changes in study factors.

For the welding parameter ranges used in this study, higher tensile-shear and T-peel failure loads were associated with larger weld diameters, better gripping of the weldment surface, reduced tip penetration, thicker weld regions, an offset of the weld zone toward the anvil side, and larger wake feature amplitudes. With the exception of average wake feature amplitudes (i.e., the average of the amplitudes of the five measured wake features, G1–G5), when welding with the flat row tip, these microstructural features were not appreciably influenced by cross section orientation, sheet rolling direction alignment, or orientation of the top sheet rolling direction relative to the vibration direction (additional detail regarding

these latter two factors is provided in the next section). Wake feature amplitudes, conversely, were found to be significantly greater for parallel cross sections and for welds in which the rolling directions of the two sheets being welded were aligned. Because test direction and sheet rolling direction were not found to significantly impact ultrasonic weld strength, however, it was concluded that while there may be a moderate correlation between larger wake structures and higher weld failure loads, the relationship does not appear to be causal.

Robustness to Aluminum Sheet Rolling Direction

Objective

Ultrasonic weldability is a function of many variables, including component

material properties, geometry, and fixturing. This study was designed to assess process robustness to one of these variables — material properties, and more specifically, sheet rolling direction. In a production application, the orientation of a welding machine with respect to the rolling lines on a component can vary greatly. It is also possible for the relative orientation of the rolling directions of the two components being joined to vary. Mitskevich (Ref. 7) found that when welding with a flat tip at small vibration amplitudes, if the rolling lines of sheets were aligned, weld shear strengths could be 25% higher than if they were perpendicular to one another. De Vries (Ref. 8) noted the possibility that surface roughness variations as a function of aluminum sheet rolling direction might impact ultrasonic weldability, but did not conduct experiments to address this issue. The objective of this study, therefore, was to ascertain whether the orientation of a welding machine with respect to the rolling lines on a sheet component or the relative orientation of the rolling directions of two components being joined is critical.

Experimental Procedure

Two scenarios, intended to frame the range of potential welding scenarios, were investigated for each of the rolling line factors. In the case of welder orientation with respect to the rolling lines on a component, welds were made with either the top sheet rolling direction perpendicular to the welding vibration direction (Fig. 12A) or the top sheet rolling direction parallel to the welding vibration direction — Fig. 12B. With respect to the relative orientation of the rolling directions of the two sheets being joined, this study examined the possibility of both alignment between the two sheets (Fig. 13A) and lack of sheet alignment — Fig. 13B. The experimental procedure was otherwise as detailed in the prior section.

Results

Again, results presented focus on those specific to the flat row tip. DOE analyses indicated that tensile-shear and T-peel failure loads and button areas were not appreciably impacted by the orientation of the top sheet rolling direction relative to the vibration direction or the relative orientation of the rolling directions of the two sheets. Figure 14 illustrates these findings, depicting failure load data as averaged, in each case, across all other factors. Error bars correspond to ± 1 standard deviation.

While tensile-shear and T-peel weld failure loads were not appreciably impacted by component rolling direction,

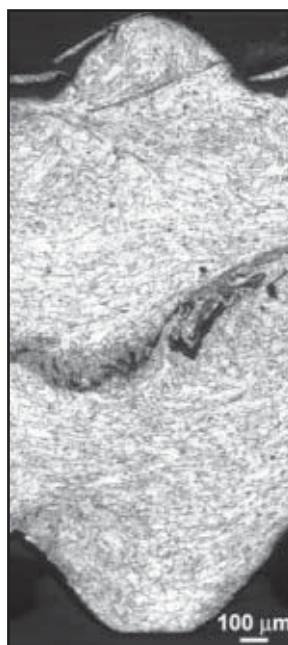


Fig. 11 — Higher magnification image of location indicated in Fig. 10.

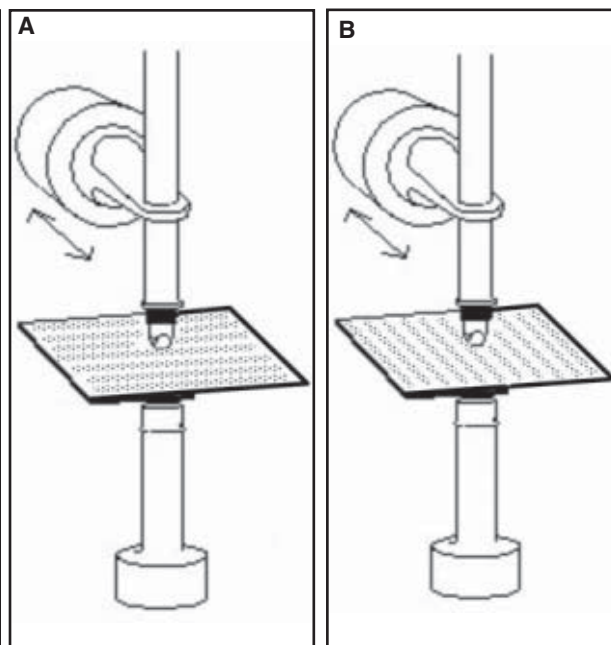


Fig. 12 — Orientation of top sheet rolling direction with respect to vibration direction: A — Perpendicular; B — parallel.

weld duration was. The voltage and current time profiles measured during welding were used to determine weld duration, i.e., the length of time during which ultrasonic electrical power was delivered to the welding machine. Weld duration was shortest when the rolling directions of the two sheets were aligned and when the rolling direction of the top sheet was parallel to the vibration input direction, as shown in Fig. 15. There were no statistically significant correlations (Pearson or Spearman's rank) at the 95% confidence level, however, between weld failure load or button area and weld duration for either the tensile-shear or T-peel specimens.

Robustness to Residual Stamping Lubricant Level

Objective

Prior work has indicated that the surface condition of aluminum workpieces can affect their ultrasonic weldability. Mitskevich (Ref. 7) reviewed literature relevant to the impact of workpiece surface preparation on resultant weld strength and found that pre-cleaning of aluminum workpieces could significantly increase bond strength and reduce its variability for a given set of weld conditions. Equivalent weld strength could be achieved in cleaned and uncleaned pieces, if additional ultrasonic energy was expended. Weare et al. (Ref. 9) found that cleaning affected the interfacial appearance of fractured aluminum welds. Harthoorn

(Ref. 10) found that the presence of lubricant on the surface of aluminum sheet influenced weld formation as did the mechanical abrasion of sheet surfaces prior to welding. Daniels (Ref. 11) determined that the surface condition of workpieces could significantly impact ultrasonic weld strength, but Mitskevich (Ref. 7) found that mechanically finishing workpiece surfaces (e.g., grinding, burring) prior to welding did not affect resultant weld strength in a consistent fashion.

Often, in North American automotive production facilities, components are not cleaned prior to welding. Rather, parts are welded with residual stamping lubricant on the surfaces. Nominal applied surface lubricant levels (i.e., 1 g/m^2) can be altered as a function of stamping and have been measured to be in the range of $0.1\text{--}1 \text{ g/m}^2$ at the time of welding. As such, a study was undertaken to determine whether the same weld parameters could produce good welds at both low and high lubricant levels.

Experimental Procedure

Experiments were conducted to determine the effects of surface lubricant level on ultrasonic weld strength, fatigue performance, and microstructural features for AA6111-T4 and AA5754 sheet. All welding was conducted using a Sonobond pedestal welding machine operated with uniform welding parameters. For each alloy, all coupons were cut from the same batch of material and ultrasonically

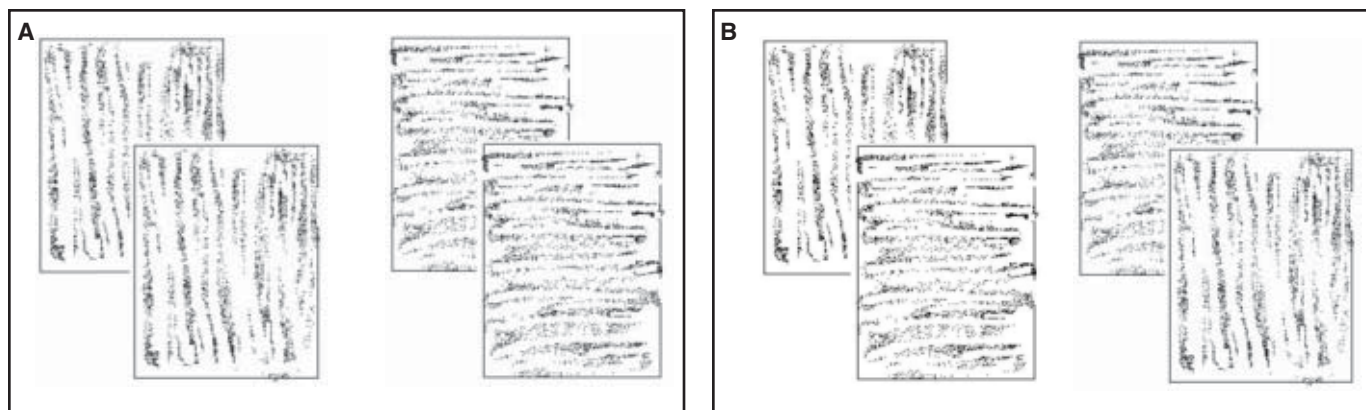


Fig. 13 — Relative orientation of rolling directions of two sheets: A — Sheets aligned; B — sheets not aligned.

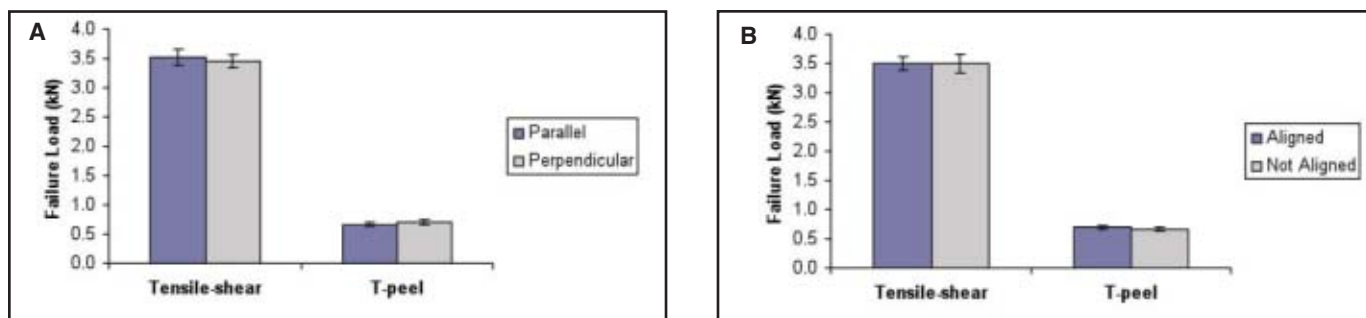


Fig. 14 — Tensile-shear and T-peel weld failure loads as a function of sheet rolling direction: A — Top sheet rolling direction orientation relative to vibration input direction; B — alignment of the rolling directions of the two sheets being joined.

cleaned in hexane prior to the controlled application of MP404 lubricant using a robotic sprayer. Three lubricant levels were evaluated as representative of actual production: 0.3, 0.6, and 1 g/m² MP404. Sample dimensions were 100 × 25 × 0.9 mm for the AA6111 coupons and 100 × 25 × 1.0 mm for the AA5754 coupons.

Forty-two AA6111 samples and 35 AA5754 samples were evaluated at each lubricant level — 9 replicates in tensile-shear and T-peel for each alloy; 3 via microstructural analysis for AA6111; and either 21 or 17 in fatigue for AA6111 (7 load levels) and AA5754 (6 load levels), respectively. T-peel samples were welded with 100% overlap and bent after welding but before paint-baking. All other samples were welded in a lap joint configuration with 25-mm overlap. To ensure consistent weldment geometry, samples were welded using a sample holding fixture. After welding, all samples were baked at 165°C for 20 min to emulate a typical automotive paint-bake cycle. Tensile-shear and T-peel testing were conducted using an Instron Model 55R1125 with a crosshead speed of 10 mm/min. Fatigue testing was conducted using an MTS closed-loop servo-hydraulic test machine with a 458 controller. A stress ratio (R) of 0.1 was employed, and testing was conducted at frequencies ranging from 1 to 30 Hz, with slow frequencies em-

ployed at the higher loads and higher frequencies at the low loads. For each weld cross section, 19 microstructural features were measured to characterize weld dimensions, tip and anvil imprints, and base material deformation, as previously detailed in Table 1 and Fig. 7.

Results

Figure 16 displays tensile-shear and T-peel failure loads as a function of lubricant level for the AA6111 and AA5754 ultrasonic welds. All four data sets — AA6111 and AA5754 tensile-shear and T-peel — exhibited homogeneity of variance, means, and medians at the 95% confidence level as a function of lubricant level. Figure 17 shows the fatigue performance of the AA6111 and AA5754 ultrasonic spot welds. Variations as a function of lubricant level were minimal. The data indicate that the strength and fatigue performance of 0.9-mm AA6111 and 1.0-mm AA5754 ultrasonic spot welds are robust to variations in residual stamping lubricant over the range of 0.3 to 1.0 g/m². In addition, no significant variations in the 19 measured microstructural features as a function of lubricant level were found. Migration of the lubricant was not explicitly evaluated in this study, but related work (Ref. 12) indicates that the lubricant is displaced from the welded region.

Robustness to Material Age

Objective

AA6111 is an Al-Mg-Si heat-treatable aluminum alloy designed for outer body applications. It is typically delivered to stamping facilities in the T4 condition in order to minimize forming difficulties, such as springback, during stamping operations. After forming and subsequent welding operations, components undergo artificial aging via a paint bake cycle. The paint bake cycle subjects the material to elevated temperature for a controlled time period, thereby stabilizing properties and resulting in increased yield stress and hence improved dent resistance. The T4 temper involves solution heat treatment followed by rapid quenching. After quenching, 6xxx series alloys can continue to age-harden for long periods of time at room temperature (Ref. 13). It is well known that material-to-material hardness variations affect ultrasonic weldability, and Kearns (Ref. 14) indicates that the energy required to make an ultrasonic weld is a function of the hardness of the material being welded. As such, this study was intended to determine the impact, if any, of coil age (i.e., shelf life post manufacture date) of AA6111-T4 on ultrasonic weldability.

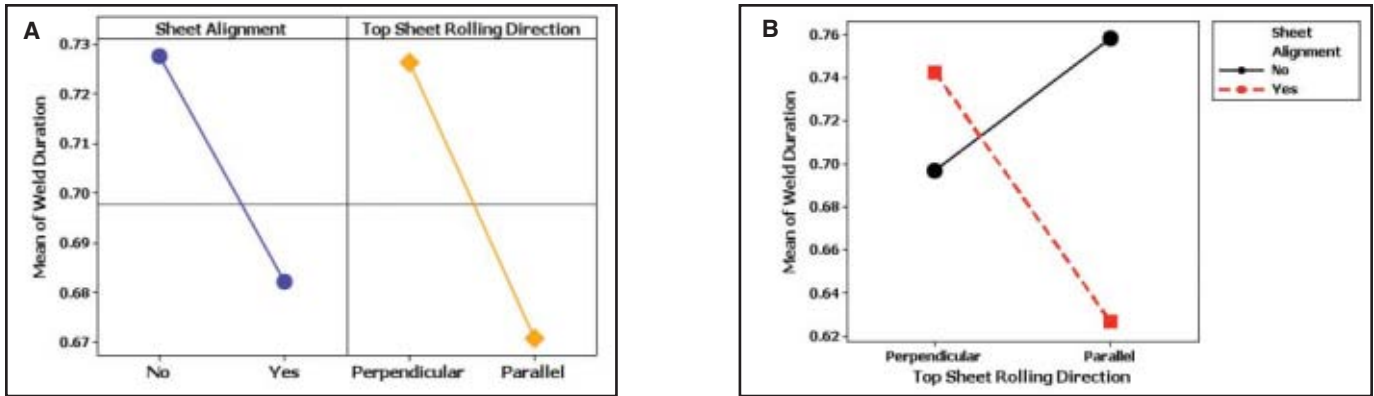


Fig. 15 — Effect of aluminum sheet rolling direction on weld duration: A — Main effects; B — two-factor interactions.

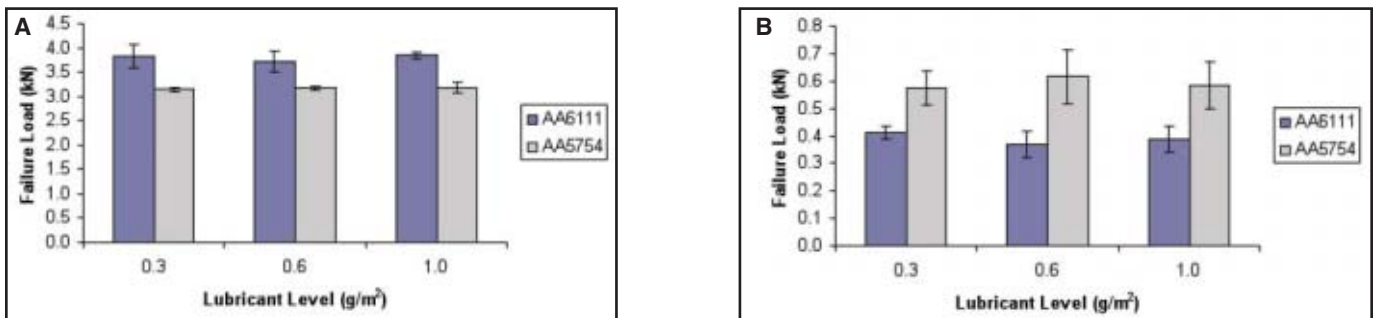


Fig. 16 — AA6111 and AA5754 tensile-shear and T-peel failure loads as a function of lubricant level: A — Tensile-shear; B — T-peel.

Experimental Procedure

A Branson Linear20 lateral-drive system was used to ultrasonically weld $100 \times 25 \times 0.9$ mm AA6111-T4 coupons in both tensile-shear and T-peel configurations. All material was taken from the same material coil, with a production date of 4/8/06. Weldability testing was initiated on 8/8/06, with subsequent testing at three (11/8/06), six (2/1/07), and twelve (8/1/07) month intervals, corresponding to material ages of ~4, 7, 10, and 16 months, respectively. On the first three of the aforementioned dates, sets of 20 welds were made for both tensile-shear and T-peel testing. On the fourth date (8/1/07), due to limited material availability, sets of only 18 welds were made for both tensile-shear and T-peel testing. All samples were baked at 165°C for 20 min after welding to simulate a typical automotive paint bake cycle. Tensile-shear and T-peel testing were conducted using an Instron Model 55R1125 with a crosshead speed of 10 mm/min.

Results

Figure 18 displays tensile-shear and T-peel failure load data as a function of material age at time of welding. The boxplots of Fig. 18 depict first (Q1) and third (Q3) quartile lines, median lines, mean values

(indicated by crosshair symbols), and outliers (indicated by asterisk symbols). Upper whisker lines extend to the highest data value within the upper limit ($Q3 + 1.5[Q3 - Q1]$), and lower whisker lines extend to the lowest value within the lower limit ($Q1 - 1.5[Q3 - Q1]$). Of the four data sets, the 7-month data are characterized by the greatest level of scatter, the lowest average tensile-shear failure load, and the highest average T-peel failure load. The 4-, 10-, and 16-month data appear similar to one another.

Statistical analyses were conducted to characterize the normality of the tensile-shear and T-peel data sets and to compare means, medians, and variances. Anderson-Darling tests for normality indicated that only four of the eight data sets followed normal distributions at the 95% confidence level. It is expected that all of the data would follow normal distributions if sample sizes were increased.

Variance equality was tested using F-tests, Bartlett's tests, and Levene's tests. Bartlett's tests and F-tests, which replace

Table 2 — P-Values for Tensile-Shear Data Mean/Median Comparisons, with Blue Numbers Indicating Mean/Median Equality at the 95% Confidence Level

	4 months		7 months		10 months		16 months	
	T-test	K-W	T-test	K-W	T-test	K-W	T-test	K-W
7 months	0.00	0.00	—	—	—	—	—	—
10 months	0.00	0.00	0.00	0.00	—	—	—	—
16 months	0.15	0.37	0.00	0.00	0.19	0.20	—	—

Table 3 — P-Values for T-Peel Data Mean/Median Comparisons, with Blue Numbers Indicating Mean/Median Equality at the 95% Confidence Level

	4 months		7 months		10 months		16 months	
	T-test	K-W	T-test	K-W	T-test	K-W	T-test	K-W
7 months	0.00	0.00	—	—	—	—	—	—
10 months	0.70	0.52	0.00	0.00	—	—	—	—
16 months	0.10	0.18	0.00	0.00	0.09	0.53	—	—

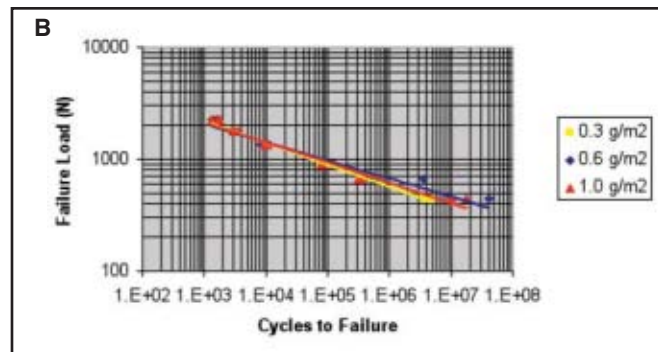
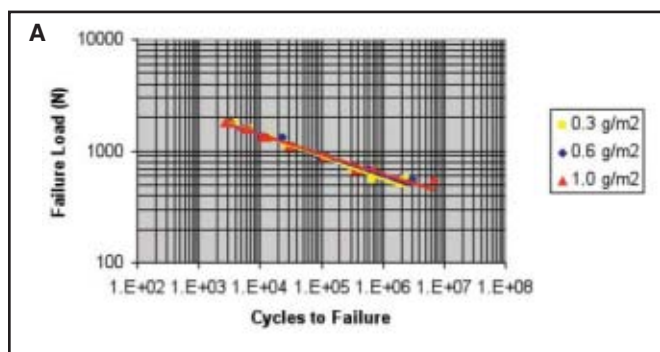


Fig. 17 — Fatigue performance as a function of lubricant level: A — AA6111; B — AA5754.

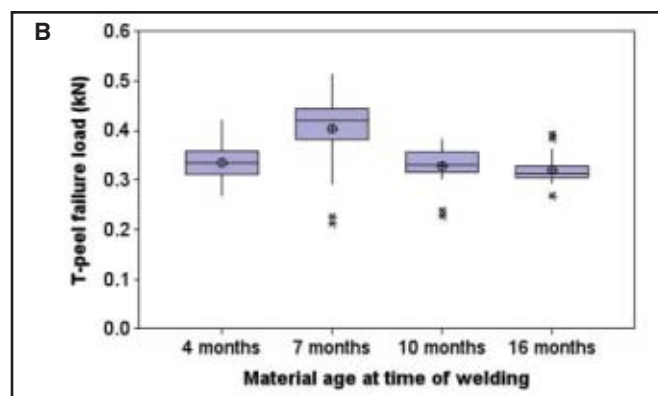
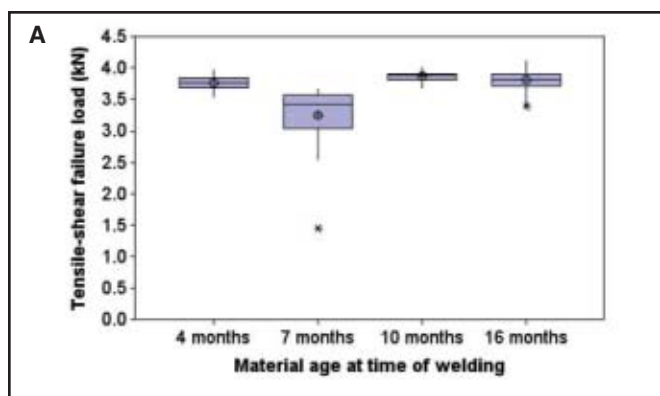


Fig. 18 — Failure load as a function of material age at time of welding: A — Tensile-shear; B — T-peel.

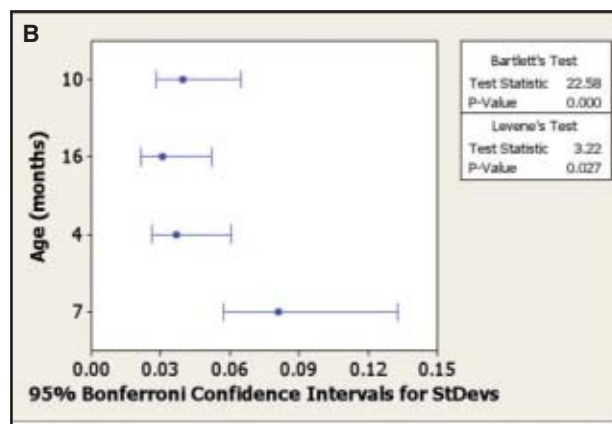
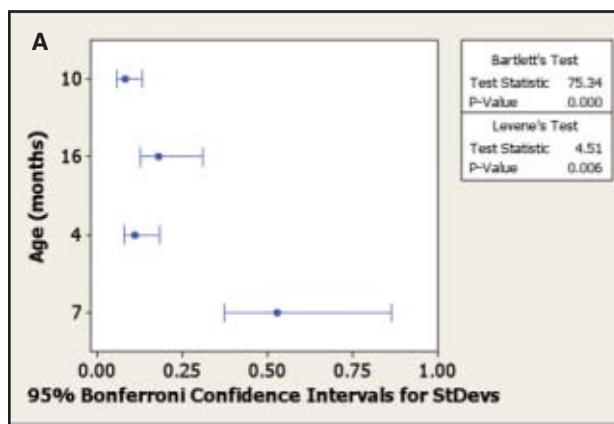


Fig. 19 — Test for variance equality. Failure load as a function of material age at time of welding: A — Tensile-shear; B — T-peel.

Bartlett's tests when there are only two levels, assume that the data come from normal distributions, while Levene's test simply assumes that the data come from continuous, but not necessarily normal, distributions. Levene's test considers the distances of the observations from their sample median rather than their sample mean. Figure 19 displays Bonferroni confidence intervals for the standard deviation and Bartlett's and Levene's test results for variance equality for the tensile-shear and T-peel data. Both Bartlett's and Levene's tests indicate vari-

ance inequality for the tensile-shear and T-peel data. The Bonferroni 95% confidence intervals for the standard deviations display significant overlap between the 4-, 10-, and 16-month samples for both the tensile-shear and T-peel data. The confidence interval for the 7-month data does not overlap with that of the other samples in the case of the tensile-shear data and only minimally overlaps with those of the other samples in the case of the T-peel data, indicating inequality of variance. Individual two-sample comparisons corroborate these findings.

Data medians were compared using the Kruskal-Wallis test, which provides a non-parametric alternative to the one-way analysis of variance (Ref. 15). Kruskal-Wallis does not assume that the data come from normal distributions. So, while the parametric test is more powerful (has a higher probability of rejecting the null hypothesis when it is false), Kruskal-Wallis is more robust against violation of the assumptions (normality and homogeneity of variance). Kruskal-Wallis assumes that samples are from continuous distributions and

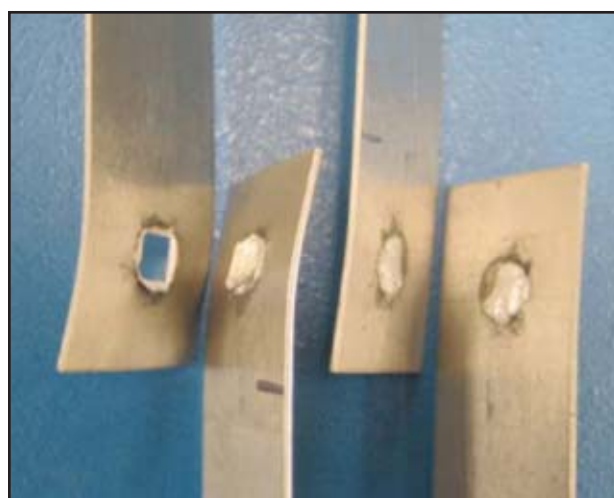
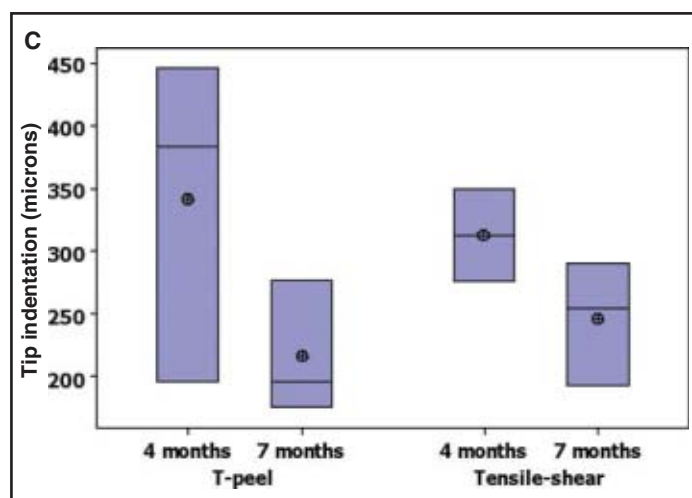
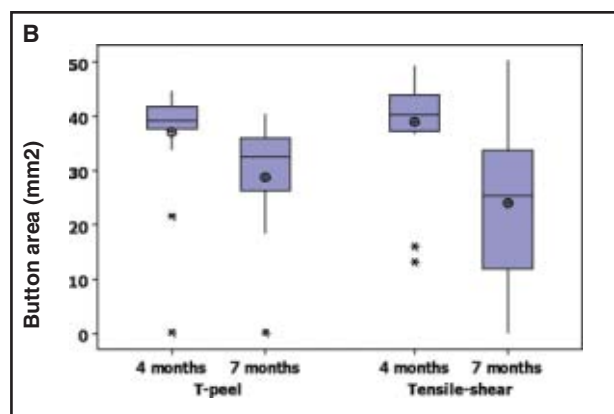
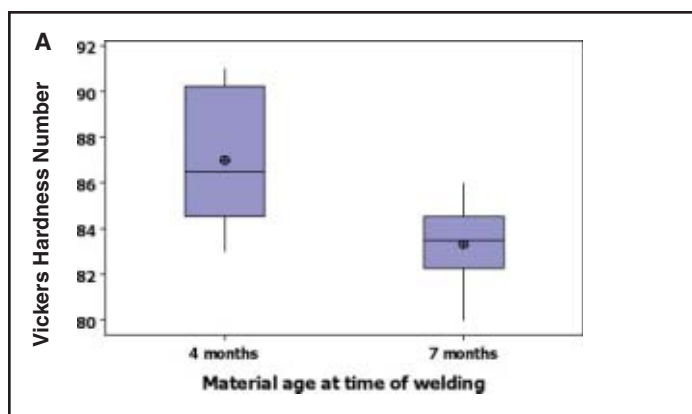


Fig. 20 — Characterization of potential noise factors in aging study: A — Vickers microhardness measurements as a function of sample batch; B — button size as a function of test type and material age at time of welding; C — tip indentation as a function of test type and material age at time of welding.

Fig. 21 — Button pull-out (left) and interfacial fracture (right) failure modes.

examines the equality of medians of the samples. Kruskal-Wallis analyses of the tensile-shear and T-peel data indicate that there are statistically significant differences at the 95% confidence level between the data medians, as a function of material age at time of welding.

Individual, two-sample comparisons were conducted to further elucidate differences between data sets. Tables 2 and 3 display the p-values associated with two sample T-tests and Kruskal-Wallis (K-W) tests between each pair of tensile-shear and T-peel data, with data sets exhibiting equality of means (in the case of the T-test) or medians (in the case of the Kruskal-Wallis test) at the 95% confidence level identified via blue highlight. Two-sample T-tests examine the difference between sample means of unknown variance; for smaller samples, they work best if data are from normal distributions. In both Tables 2 and 3, results from the T-tests and the Kruskal-Wallis tests are in agreement. In the case of the tensile-shear data (Table 2), the 16-month data

means and medians are indistinguishable from the 4- and 10-month values. In the case of the T-peel data (Table 3), the 4-, 10-, and 16-month data are identical at the 95% confidence level with respect to mean/median values. As was the case with the variances, the 7-month data set stands out as the anomaly.

Increases in yield strength in heat treatable aluminum alloys due to age hardening are a continuous function of time over time periods significantly longer than 16 months (Ref. 13). As such, it can be concluded that the anomalous data at the 7-month mark in this study is likely attributable to an irregularity in the experimental procedure, rather than a true variation in ultrasonic weldability as a function of material age. It should be noted that potential sources of error which were controlled during this study were material (all material was from the same coil), specimen size (all coupons were sheared to nominally identical dimensions), and welding parameters. As such, principal outstanding sources of variation might include

welding tool mount, welder operation, and postweld bake cycle.

The possibility of variations in the temperature and/or duration of the bake cycle to which samples were subjected after welding was assessed using material hardness measurements. Vickers microhardness testing was conducted on two coupons each from the 4- and 7-month batches (Fig. 20A), at a location remote from the weld site. It should be noted that prior work (Ref. 1) has revealed no evidence of significant hardness variation between the weld region and the base metal for ultrasonic spot welds in 6XXX series aluminum. A statistically significant difference in mean hardness values (and hence material yield stress, Ref. 16) at the 95% confidence level was determined for this small sample set, but the ~4% change in hardness values cannot alone account for the ~14% change in tensile-shear failure load.

Weld failure morphology was also examined as a potential factor for the anomalous data at the 7-month material age, in

particular because the 7-month data are characterized by lower tensile-shear strength but higher T-peel strength. All 20 tensile-shear samples and 19 of the 20 T-peel samples welded at 4 months material age failed via button pull-out, as depicted in Fig. 21. The alternative failure mode is interfacial fracture and is also depicted in Fig. 21. Eighteen of the 20 samples welded at 7 months material age failed via button pull-out in both tensile-shear and T-peel. Button shape was quite consistent throughout. Button area as a function of material age at time of welding is shown in Fig. 20B for both tensile-shear and T-peel samples. The T-peel data displayed homogeneity of variances at the 95% confidence level, but the tensile-shear data demonstrated variance inequality as a function of material age. For both the tensile-shear and the T-peel data, there were statistically significant differences (p -value < 0.05) in mean and median button size as a function of material age at time of welding, with the decrease in mean tensile-shear button area being 70% greater than the decrease in mean T-peel button area. Tensile-shear button area correlated moderately well with tensile-shear failure load, but the T-peel data did not exhibit a similar statistically significant correlation.

Tip indentation was examined as a potential indicator of differences in welding machine operation between the data sets and hence explanation for the anomalous strength data at the 7-month material age. While tip indentation appears lower for the 7-month data as shown in Fig. 20C, the difference was not statistically significant.

In summary, while a comprehensive evaluation of all potential noise factors contributing to the anomalous strength data at the 7-month material age is not possible post experiment, the aforementioned analyses do indicate the existence of slight irregularities in the experimental procedure associated with that experimental batch. Microhardness variations indicate post-weld bake cycle inconsistencies that are in line with the observed 7-month weldment strength disparities. Differences in tip indentation and tensile-shear and T-peel button sizes also indicate that welding machine operation and/or welding tool mount may have been dissimilar for the 7-month data set. Therefore, as previously stated, it was concluded that the anomalous data at the 7-month mark in this study is due to an irregularity in the experimental procedure, rather than a true variation in ultrasonic weldability as a function of material age.

Conclusions

Requisite to the implementation of ultrasonic metal welding in automotive body construction applications is demonstration of process robustness to manufacturing variables. In this study, process robustness

to four critical issues — weld orientation, aluminum sheet rolling direction, residual stamping lubricant level, and material age — has been established. Ultrasonic weld tensile-shear and T-peel failure loads and button sizes were not found to vary significantly as a function of weld orientation. Despite the directional nature of the energy input by linear ultrasonic welding systems, weld strength was essentially equivalent parallel to and perpendicular to the vibration input direction. In addition, tensile-shear and T-peel failure loads and button areas were not appreciably impacted by the orientation of the top sheet rolling direction relative to the vibration direction or the relative orientation of the rolling directions of the two sheets being joined. While weld duration was influenced by component rolling direction, there were no statistically significant correlations between weld failure load or button area and weld duration for either the tensile-shear or T-peel specimens. Ultrasonic weld strength, fatigue performance, and microstructural features for 0.9-mm AA6111 and 1.0-mm AA5754 sheet were determined to be robust to variations in residual stamping lubricant (MP404) over the range of 0.3 to 1.0 g/m². Finally, coil age in the range of 4 to 16 months was not found to impact the ultrasonic weldability of AA6111-T4, as characterized using tensile-shear and T-peel weld failure loads. In summary, ultrasonic metal welding process robustness to weld orientation, aluminum sheet rolling direction, residual stamping lubricant level, and material age have been demonstrated. These findings are important for the implementation of ultrasonic metal welding in automotive body construction applications.

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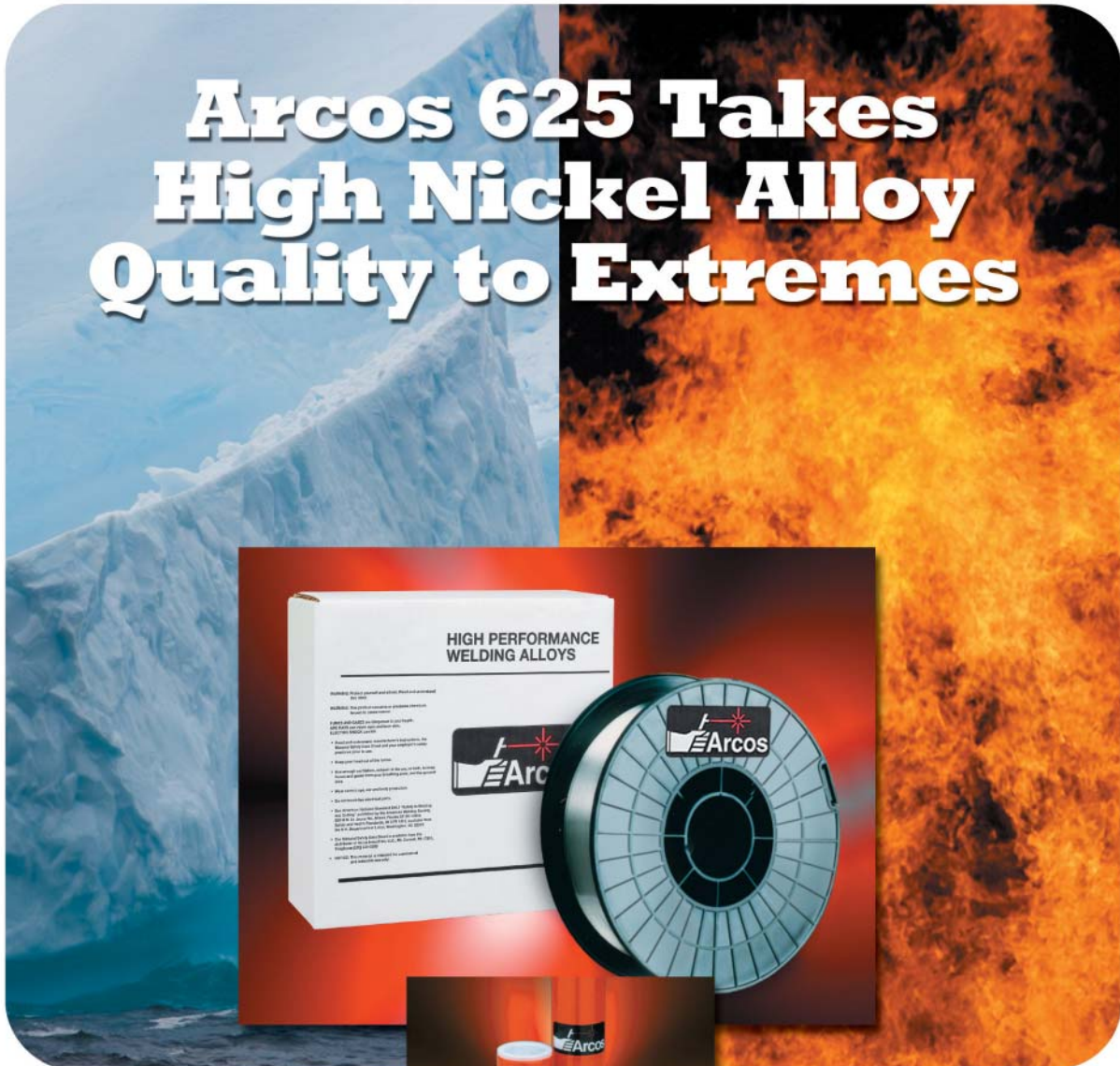
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