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Hodgson Custom Rolling Inc. is one of North America’s largest plate rolling, forming, section rolling and fabricating companies.

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Hodgson Custom Rolling Inc.

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On the cover: The Hywind pilot project is shown at the test place west of Karmøy, an excellent site with steady, good, and challenging winds averaging 10 m/s year-round. (Photo courtesy of Trude Refsahl/Statoil.)
Lincoln Electric Celebrates Its 115th Anniversary

The Lincoln Electric Co., Cleveland, Ohio, is celebrating its 115th year in business.

“We hold the same values today that John C. Lincoln held that day in 1895 when the company first opened for business,” said John M. Stropki, chairman and chief executive officer. “As we celebrate our 115th anniversary as the leading innovator in the arc welding industry, we maintain our enduring passion for the development and application of welding technologies that constantly provide better solutions to our customers’ needs.”

Throughout its 115 years, Lincoln has forged many technology advancements, and it continues to update and expand product lines. Also, the company recently opened a new welding consumables plant in India, acquired Jinzhou Jin Tai Welding and Metal Co., Ltd., in China, and dedicated a 100,000-sq-ft Automation Center of Excellence adjacent to its world headquarters in Cleveland.

Presently, Lincoln has manufacturing locations, including operations and joint ventures, on five continents, plus a worldwide network of distributors and sales offices covering more than 160 countries.

SME Creates AeroDef Manufacturing Exposition, Starts Biennial WESTEC Show

The Society of Manufacturing Engineers (SME), Dearborn, Mich., recently announced AeroDef Manufacturing, a new exposition scheduled for launch April 5-7, 2011, at the Anaheim Convention Center, Anaheim, Calif. The event will address the way commercial and military aircraft are designed, developed, and produced, and will emphasize technologies that trim delivery times and control costs presented by experts in the industry. The expo will alternate years with the WESTEC Advanced Productivity Exposition. Visit http://aerodef.sme.org for more information.

WESTEC 2012 is scheduled for March 27-29, 2012, at the Los Angeles Convention Center. The show will highlight how technologies originally created for aerospace and defense have application in industries such as medical, energy, electronics, consumer goods, aircraft, general manufacturing, and the automotive aftermarket. The redesigned exposition will have an emphasis on best business practices. To learn more, visit www.westeconline.com.

Survey Shows Engineering Majors Dominate Job Market

In the winter 2010 salary survey by the National Association of Colleges and Employers, most of the top ten disciplines are engineering fields, and graduates with bachelor’s degrees are earning among the highest salaries. This reinforces a June 2009 Forbes.com article that reported engineer is one of the hardest jobs to fill in America.

All of this bodes well for engineering graduates such as those from Worcester Polytechnic Institute, Worcester, Mass. Worcester grad have high placement rates and starting salaries that exceed the national average, even in the challenging financial climate. A reason these graduates are in high demand with employers is that they have gained valuable experience before graduating thanks to the university’s project-based curriculum where students work in teams and apply their knowledge to solve real-world problems in communities around the world.
What’s the most efficient way to produce your wind tower? Turn to ESAB for a complete manufacturing solution. We have everything you need, all in one place – from mechanized cutting machines to automated welding systems to the broadest selection of filler metals and fluxes. Our experts will provide a turnkey solution, from factory layout to unequalled support that will keep your operation running at maximum efficiency. So let ESAB power the fabrication of your wind tower.
Welding’s Brain Drain Crisis

What does the word welding mean to you? In particular, what does it mean if you are a young student searching for the “right” career path to follow? To many, it carries the connotation of manual labor, dirty fingernails, fumes, hazardous work environment, hard work, little sophistication, not green, dead-end job,... etc. Unfortunately, the notion that welding is a matured technology that undergoes little innovation has been around for years, amply accepted by government leaders and elite institutions. Following that short-sighted view, support for welding education and research development has dwindled to its lowest level in decades. In the midst of the longest and deepest economic recession since the Great Depression of the 1930s, everything turns on the bottom line, further cutting into the little incentives given to welding development and education.

Misfortune never comes singly.

At the same time that U.S. industries struggle to survive, they are also experiencing an increasing shortage of technical staff. The current demographic distribution of engineering staff members in U.S. industries is clearly bimodal, with a large group approaching the big six-oh and another group around their early 40s. The age bimodal distribution is also accompanied by a similar distribution in experience and expertise. With the growing number of retirements, this gap will become progressively wider, with risks of losing corporate memory and proliferation of “reinventing the wheel” syndrome. Are we faced with an eminent two decade deficit of engineering staff? How is industry reacting to this alarming reality? Although outcries have been occasionally heard on this somber situation, far more drastic plans and actions must be taken to promote engineering and manufacturing amongst U.S. youth, to recruit and prepare candidates for the engineering specialties that have the greatest needs, and to attract and place these engineering graduates to balance the shrinking pool of talents.

An even more alarming situation that has received relatively little attention is also looming on the American horizon. High-caliber educational programs to prepare specialists in welding and joining in the United States have significantly decreased in the past decades. Will the universities be able to replenish the number of skilled engineering staff for the U.S. manufacturing and fabrication industries? With government- and industry-sponsored research budgets declining extensively in welding and joining, many academic researchers have been drawn away from these areas to others that are more “lucrative” or offer more promising short-term returns. The danger of this exodus is that with time, the number of instructors with bona fide welding and joining background and training will decrease. Consequently, the number of courses focused on welding and joining offered in colleges across the United States will rapidly decrease, diminishing the opportunities for engineering students to specialize in these fields. Furthermore, with a steady loss of expertise, even the offered courses may become more survey in nature, without the required depth and substance for thorough preparation of specialists. The most obvious loss today in terms of teaching and research talents is in the field of primary metals and processing. The interest of students also decelerated. All these factors will contribute to weakening the development of future teachers in the field of welding and joining.

To mitigate the current talent shortage that is anticipated to last for the next two decades, it is time to set in motion the triple alliance — government, industry, and educational institutions. The vision should be set high to go beyond short-term gains and interests and to uphold the future of the United States by rebuilding the manufacturing base in America. With the government providing long-term vision and leadership, industry investing in responsible and sustained growth, and universities nurturing and preparing the required manpower and talent, the days of the U.S. economic crisis are numbered!

Stephen Liu
Chair, AWS Technical Papers Committee
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Wind Tower Fabrication Strengthens alongside Energy-Efficient Trends

Siemens Expands Wind Blade Plant, Creates Global 60-Hz Turbine Hub in the U.S.

Siemens will build a new 60-Hz gas turbine production plant at its existing facility in Charlotte, N.C. The company plans to create a global production center for manufacturing, servicing, and extra support functions related to the supply of its gas and steam turbines and generators to 60-Hz markets worldwide. The initial investment will be approximately $135 million, and production is slated to start in fall 2011.

“Over the next five years, we expect employment at the Charlotte site to grow to nearly 1800 people, with more than 1000 of those positions new to Charlotte,” said Peter Loscher, president and CEO of Siemens AG. Some 825 new positions will be for the planned gas turbine production as well, while 226 new jobs were previously announced last October.

“Furthermore, just in the past three years, Siemens has opened — and subsequently expanded — a wind turbine blade manufacturing plant in Fort Madison, Iowa, now with more than 400 employees, and a second production plant for wind turbine gearboxes in Elgin, Ill., with up to 350 new jobs. The company also is in the process of building a plant in Hutchinson, Kans., which will employ another 400 people who will make nacelles for our wind turbines. Just within the wind business we are adding more than 1000 green jobs to our U.S. workforce,” added Loscher.

The production of 60-Hz gas turbines at the Hamilton site in Canada will be phased out, but this decision does not impact the production of gas turbines for 50-Hz markets at the Berlin hub in Germany.

Gamesa and BARD Partner Up for Offshore Wind Market

Gamesa, Spain, signed a memorandum of understanding with BARD Holding GmbH, Emden, Germany, for joint development and marketing of offshore wind turbines and services. The agreement envisages an investment by Gamesa for a minority stake in BARD as well as the creation of a joint venture to sell solutions and provide services in the offshore wind power market. It may also enable Gamesa to develop manufacturing facilities to produce BARD offshore wind turbines under licensing contracts. The companies agreed on a negotiating period to structure this collaboration.

ZargesTubesca Division Wind Breaks Ground for Texas Facility

ZargesTubesca Division Wind, a German company, recently broke ground on a $5 million manufacturing facility that will cover 80,000 sq ft in Amarillo, Tex. This building is a project of the Amarillo Economic Development Corp. Ladders, service lifts, platforms, and fittings for wind towers are set to be manufactured at this new location. Amarillo College, Amarillo, Tex., will provide aluminum welding training, and a welding system is being donated for this purpose, according to Dr. Kim Hays, the college’s manufacturing department head.

The CEO of ZargesTubesca Group, Frank Haberstroh, and CEO of ZargesTubesca Division Wind, Bernd Gopfert, both from Weilheim, Germany, attended the ceremony. The following individuals were also present: Minister Christoph Eichhorn, director of the political department from the German Embassy in Washington; Ben Bücker, honorary consul of the Federal Republic of Germany; and Jan Christopher Wiedemann, managing director of the German-American Chamber of Commerce.

ZargesTubesca Division Wind’s facility is expected to bring 100 jobs to Amarillo within a five-year time period.
A scene at the ground-breaking ceremony for the future home of ZargesTubesca’s facility in Amarillo, Tex. The company will manufacture wind tower ladders, service lifts, platforms, and fittings.

the company operates with a small business office in downtown Amarillo with the team led by Tim Dannels, managing director of the ZargesTubesca U.S. division. Construction on the new facility has begun, and CIB was selected as the primary contractor. It is expected to be in operation by this October.

China’s Offshore Wind Farms Nearly Done

The first two installations in a large clean-energy project — the 102-MW Shanghai Donghai Bridge with 34 turbines and 201-MW Jiangsu Xiangshui project making up 134 turbines — are approaching completion. These two wind farms are the first of what is expected to be a surge of offshore wind parks as China utilizes its natural resources. The country is committed to produce at least 100 gigawatts of offshore wind power by 2020.

All 168 turbines will be equipped with ABB power products, which have passed the requirements of the turbine manufacturer, Shanghai Electric Wind. Both parks are scheduled to be fully operational by 2011.

Sierra College Wins $205,000 Grant for Training Energy Technicians

The Center for Applied Competitive Technologies (CACT) at Sierra College, Rocklin, Calif., has been selected to receive a $205,000 grant from the California Community College Chancellor’s Office, Economic and Workforce Development Program. It will focus on manufacturers and train energy technicians to identify and implement energy-saving practices.

The project includes a demonstration site to assist manufacturers in utilizing energy audits, weatherization, and other methods to reduce energy consumption without outlay of capital investment. In partnership with the California Conservation Corps, Auburn, Calif., CACT will develop curriculums to train Corps members to fill the need for energy efficiency technicians. This project will give local manufacturers cost-saving advantages, generate new businesses, open ‘green collar’ career paths to well-paid jobs, and develop workers’ skills. Plus, Butte College and College of the Redwoods are grant partners, and the California Conservation Corps Placer Energy Center will play a role.

Jay Leno Honored by Lincoln and AWS

Two presentations were recently made to The Tonight Show host Jay Leno by The Lincoln Electric Co. and the American...
Jay Leno poses with the Hot Bikes, Fast Cars, Cool Careers DVD plaque joined by (from left) AWS Executive Director Ray Shook; Lincoln Electric’s Event Marketing Manager, Scott Skrjanc; and Senior Vice President Global Marketing and Product Development, Richard Seif; and AWS Foundation Executive Director Sam Gentry.

Welding Society (AWS). These were given for assistance with the Hot Bikes, Fast Cars, Cool Careers DVD where he promoted his admiration for welders and support for welding as a career and led to him achieving an AWS National Meritorious Award. Leno is an avid car and motorcycle collector, enthusiast, and vehicle restorer.

At the awards event Richard Seif, senior vice president global marketing and product development, and Scott Skrjanc, event marketing manager, represented Lincoln Electric. In attendance on behalf of AWS were Ray Shook, executive director, and Sam Gentry, executive director, AWS Foundation.

Leno made a video endorsing welding as a career and recom-
mending his fans contact AWS. On YouTube, this can be viewed at www.youtube.com/watch?v=PASEG5xL1Ro.

“It’s interesting this country was built by welders, and somewhere along the line, we kind of lost our focus...you could actually do something that actually helps the country fix our infrastructure, build bridges,” Leno said of the trade. In addition, Leno conducted an interview with Shook during which AWS, the current high demand for welders, and benefits of a welding career were discussed. This is posted on “Jay Leno’s Garage” Web site at www.jaylenosgarage.com.

“I like the fact that you can actually make and fix something that will last literally a lifetime,” Leno said of welding.

**Alabama Welding Instructors Attend Resource Center Workshop**

The Resource Center for Technology, a nonprofit educational training center, recently held its fifteenth annual Technical Update Workshop for Alabama welding instructors.

“All of the persons who work with us to conduct this workshop put much effort into providing up-to-date training for the instructors. There is no doubt as to how well it has paid off,” said Bob Kimbrell, president and CEO of the Resource Center for Technology.

Alabama technical teachers are required to obtain 16–20 h of technical update training each year for maintaining certification.

During the workshop, welding educators from Alabama used new welding equipment and practiced new techniques. Susan Rossman, technical training supervisor, Southern Co. Services, tried Lincoln Electric’s virtual welding system (top photo) while Dan Klingman of Lincoln explained how it worked. Robert Shepherd, district manager, Miller Electric, also lectured about torch safety.
Business, industry, secondary and postsecondary instructors, vendors, and apprentice trainers came together for the event. Its hosts included Randy Kelly, an apprentice coordinator, who represented the Plumbers and Pipefitters Union Local 372, Tuscaloosa, Ala.

“We view the opportunity for manufacturers, educators, and skilled trades representatives to come together and share the latest in safety, training, technology, and industry trends a win-win-win situation,” said Troy Gurkin, Lincoln Electric, Birmingham district manager.

Presentations were made on various topics. Miller Electric Manufacturing Co. provided information about aluminum welding and welding safety; UA Apprentice Trainers detailed rollout welding — the fabrication shop way; The Lincoln Electric Co. presented training on virtual reality welding tools, advanced technology process monitoring, and gave an environmental safety update; and ESAB Welding & Cutting Products featured aluminum welding applications, material preparation, weld discontinuities, and filler metal selection. Airgas was present at the program as well, and Connie Bowling, director of the American Welding Society’s Solutions Opportunity Squad, attended the event.

“Every one that I attend I leave as a better, more complete instructor able to prepare my students to make their lives richer than I would have without the workshop,” said Roy L. Ledford, advisor for the AWS Lawson State Community College Student Chapter, Bessemer, Ala.

North Carolina University Studies Impact of Welding Gases

The North Carolina Agricultural & Technical State University’s School of Manufacturing Technology partnered with Regula Systems, LLC, Greensboro, N.C., to investigate the environmental impact of reducing consumption of shielding gases used in large industrial welding applications.

The company’s Electronic Welding Regulator reduces carbon emissions (greenhouse gases) associated with welding gases by as much as half at installations throughout Europe and Asia. Regula will provide equipment, technical support, and funds for this graduate level study, which will be made through June 2010. The study’s objective is to demonstrate the amount of carbon emissions reduction that can be achieved using this new technology.

Additional collaborative efforts and installations are underway with several vehicle and metal manufacturing companies in North Carolina and Virginia.

Industry Notes

• Gagemaker, LP, Houston, Tex., donated inspection gauges and industry information to the Northern Alberta Institute of Technology, Edmonton, Alb., Canada, for its machinist program.

• NEWCO Industries, Litchfield, Mich., a provider of custom fabrication, welding, and powder coating services, is changing its name to NEX Solutions.

• The GREENGUARD Environmental Institute, Atlanta, Ga., redesigned its Web site at www.greenguard.org offering manufacturers a guideline for certifying products, materials for low chemical emissions, and a technical center.

• Southwire Co., Carrollton, Ga., completed the asset purchase of Rhode Island-based American Insulated Wire Corp. with its brands and two facilities in Georgia and Kansas.
The Cascade Die Casting Group, Inc. plant in Sparta, Mich., plans to add five to eight employees after buying a new melt furnace that, according to company spokesman David Bowman, will increase production of aluminum alloy products.

Lone Star College-CyFair, Cypress, Tex., has started Spanish language welding courses beginning with Shielded Metal Arc Welding, Part 1. Additional courses are planned.

Globe Specialty Metals, Inc., reopened its silicon metal and ferrosilicon alloys facility in Alabama that was idled during the economic downturn and also reopened its Niagara Falls, N.Y., plant.

Rehm Thermal Systems moved into a new Applications Center in Roswell, Ga., designed to provide users with convection and condensation soldering systems. The company is celebrating its 20th anniversary this year.

Adept Technology, Inc., Pleasanton, Calif., received a $4.1 million order for high-precision robots from an international manufacturer of automation equipment. Also, the company participated with academic, industry, and nonprofit organizations to launch National Robotics Week last month.

Moody International, UK, acquired Pro-Inspect, Inc., based in La Porte, Tex., and Geismar, La., an in-service maintenance inspection and engineering support services provider.

American Axle & Manufacturing Holdings, Inc., established the Lancaster Manufacturing Facility in Lancaster, Pa. At 30,000 sq ft, it expands the company’s welding and bare spindle axle assembly capacity for the Class 8 commercial truck market.

The University of Phoenix created a partnership with The Manufacturing Institute to develop curriculums relevant to today’s manufacturing workforce aligned with the NAM-endorsed Manufacturing Skills Certification System.

Pace Industries, Fayetteville, Ark., a large custom aluminum die casting company, acquired the zinc die casting business of Del Mar Industries Inc.

Airgas, Inc., Radnor, Pa., and XCOR Aerospace, a developer and producer of reusable rocket-powered vehicles and propulsion systems, have formed a 15-year product sales and sponsorship agreement.

A Stevie® Award in the Customer Service Department of the Year category was awarded to TRUMPF Inc., Farmington, Conn.

GH Electrothermia S.A., a supplier of induction heating equipment, purchased a majority interest in Induction Atmospheres, Rochester, N.Y., now known as GH Induction Atmospheres.

United & Taylor Welding Supply opened a Malta, N.Y., location to be closer to the GlobalFoundries construction project. This store is located inside Luther Forest Technology Campus.

Welding Technique Produces Structures without Fixtures or Additional Tooling

Researchers at Cranfield University, Cranfield, UK, recently developed a welding technique for manufacturing horizontal and inclined structures without the need for additional tooling or any type of fixtures or waste materials. The discovery is part of the university’s research on Ready-to-Use Additive Manufacturing (RUAM), which aims to improve industry’s ability to manufacture high-precision, ready-to-use functional parts for a range of applications from small turbine blade repairs to large aerospace structures.

The RUAM process can produce a range of geometries and features to fit various demands. It uses additive layer welding techniques such as cold metal transfer, which allows for flexible welding strategies at high speeds. Currently, deposition rates of more than 1 kg/h are possible. The process also allows for the mixing of strategies and materials and for amending existing metal workpieces. Software for automatically generating robot paths has also been developed as part of the project.

As part of the research, the Cranfield team investigated the fabrication of angled steel walls without the use of any kind of support structures. A series of experiments was conducted using an “inclined torch” method, resulting in the successful production of a series of inclined walls varying from 60 to 15 deg. In addition, they created a horizontal wall section, initially as an extension of an existing horizontal section, and tested in the form of a box structure.

The more than $3 million project began in late 2007. It is currently supported by 21 industry partners including Airbus, Doncasters, and Bombardier. Two UK universities are involved with the project. For more information, visit www.cranfield.ac.uk.

Training Course Developed to Help Secure Skilled Welders for South Australia

SA Water and AdelaideAqua have launched a training program as part of a joint initiative to plan for and secure the availability of skilled welders for the $1.8 billion Adelaide Desalination Project. The aim of the Welding Training and Testing Initiative is to attract, train, and enhance the skilled resource capacity in the area of specialized welding, welding supervision, and welder qualifications.

“The need for skilled welders was identified as part of the joint initiatives being run by SA Water and AdelaideAqua, and builds on key lessons learnt from previous projects,” AdelaideAqua Project Director Paul Tracey said. “Within our state, the metal and engineering industry has reported a lack of available skilled workers, with many large contractors often forced to look interstate and overseas to satisfy project-based work.”

The desalination project will use more than 4000 m of site-run superduplex and other stainless steel pipes and fittings.

Tracey said he envisioned the creation of a specialized welding expertise and resource pool that will benefit many local industries long after the project’s completion date.

Waterjet Manufacturers Announce R&D Partnership

Through a strategic research and development partnership, Italian waterjet equipment manufacturer Tecnocut will share this IKC 5-axis waterjet cutting technology with Jet Edge, St. Michael, Minn., and Jet Edge will share its 90,000 lb/in.² waterjet intensifier pump technology with Tecnocut. The companies have also agreed to partner on a number of projects related to waterjet pump design, multiaxis cutting, and robotics. Additional information about the companies is available at www.tecnocut.it and www.jetedge.com.

Dutch Company Acquires UK Fall Protection Firm

XSPlatforms, Gorinchem, The Netherlands, recently acquired High Level Safety (HLS), a UK company that specializes in providing fall arrest and other systems to prevent falls from heights for the commercial and industrial sectors.

High Level Safety will become XSPlatforms UK. The new company will offer the complete range of XSPlatforms products. The initial focus of the new company will be on fall protection and building maintenance units. All HLS employees will become part of the new company.
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Friends and Colleagues:

I want to encourage you to submit nomination packages for those individuals whom you feel have a history of accomplishments and contributions to our profession consistent with the standards set by the existing Fellows. In particular, I would make a special request that you look to the most senior members of your Section or District in considering members for nomination. In many cases, the colleagues and peers of these individuals who are the most familiar with their contributions, and who would normally nominate the candidate, are no longer with us. I want to be sure that we take the extra effort required to make sure that those truly worthy are not overlooked because no obvious individual was available to start the nomination process.

For specifics on the nomination requirements, please contact Wendy Sue Reeve at AWS headquarters in Miami, or simply follow the instructions on the Fellow nomination form in this issue of the Welding Journal. Please remember, we all benefit in the honoring of those who have made major contributions to our chosen profession and livelihood. The deadline for submission is July 1, 2010. The Committee looks forward to receiving numerous Fellow nominations for 2011 consideration.

Sincerely,

Nancy C. Cole
Chair, AWS Fellows Selection Committee
DEFINITION AND HISTORY
The American Welding Society, in 1990, established the honor of Fellow of the Society to recognize members for
distinguished contributions to the field of welding science and technology, and for promoting and sustaining the professional
stature of the field. Election as a Fellow of the Society is based on the outstanding accomplishments and technical impact of the
individual. Such accomplishments will have advanced the science, technology and application of welding, as evidenced by:
* Sustained service and performance in the advancement of welding science and technology
* Publication of papers, articles and books which enhance knowledge of welding
* Innovative development of welding technology
* Society and chapter contributions
* Professional recognition

RULES
1. Candidates shall have 10 years of membership in AWS
2. Candidates shall be nominated by any five members of the Society
3. Nominations shall be submitted on the official form available from AWS Headquarters
4. Nominations must be submitted to AWS Headquarters no later than July 1 of the year prior to that in
   which the award is to be presented
5. Nominations will remain valid for three years
6. All information on nominees will be held in strict confidence
7. No more than two posthumous Fellows may be elected each year

NUMBER OF FELLOWS
Maximum of 10 Fellows selected each year.

AWS Fellow Application Guidelines
Nomination packages for AWS Fellow should clearly demonstrate the candidates outstanding contributions to the advancement
of welding science and technology. In order for the Fellows Selection Committee to fairly assess the candidates qualifications, the nomination
package must list and clearly describe the candidates specific technical accomplishments, how they contributed to the advancement of welding technology, and that these contributions were sustained. Essential in demonstrating the candidates impact are the following (in approximate order of importance).

1. Description of significant technical advancements. This should be a brief summary of the candidates most
   significant contributions to the advancement of welding science and technology.
2. Publications of books, papers, articles or other significant scholarly works that demonstrate the contributions cited
   in (1). Where possible, papers and articles should be designated as to whether they were published in
   peer-reviewed journals.
3. Inventions and patents.
4. Professional recognition including awards and honors from AWS and other professional societies.
5. Meaningful participation in technical committees. Indicate the number of years served on these committees and
   any leadership roles (chair, vice-chair, subcommittee responsibilities, etc.).
6. Contributions to handbooks and standards.
7. Presentations made at technical conferences and section meetings.
8. Consultancy — particularly as it impacts technology advancement.
9. Leadership at the technical society or corporate level, particularly as it impacts advancement of welding technology.
10. Participation on organizing committees for technical programming.
11. Advocacy — support of the society and its technical advancement through institutional, political or other means.

Note: Application packages that do not support the candidate using the metrics listed above
will have a very low probability of success.

Supporting Letters
Letters of support from individuals knowledgeable of the candidate and his/her contributions are encouraged. These
letters should address the metrics listed above and provide personal insight into the contributions and stature of the
candidate. Letters of support that simply endorse the candidate will have little impact on the selection process.

Return completed Fellow nomination package to:
Wendy S. Reeve
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SUBMISSION DEADLINE: July 1, 2010
CLASS OF 2011
FELLOW NOMINATION FORM

DATE______________________NAME OF CANDIDATE______________________

AWS MEMBER NO.______________________YEARS OF AWS MEMBERSHIP______________________

HOME ADDRESS______________________

CITY______________________STATE______________________ZIP CODE______________________PHONE______________________

PRESENT COMPANY/INSTITUTION AFFILIATION______________________

TITLE/POSITION______________________

BUSINESS ADDRESS______________________

CITY______________________STATE______________________ZIP CODE______________________PHONE______________________

ACADEMIC BACKGROUND, AS APPLICABLE:

INSTITUTION______________________

MAJOR & MINOR______________________

DEGREES OR CERTIFICATES/YEAR______________________

LICENSED PROFESSIONAL ENGINEER: YES______NO______STATE______________________

SIGNIFICANT WORK EXPERIENCE:

COMPANY/CITY/STATE______________________

POSITION______________________YEARS______________________

COMPANY/CITY/STATE______________________

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SUMMARIZE MAJOR CONTRIBUTIONS IN THESE POSITIONS:

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IT IS MANDATORY THAT A CITATION (50 TO 100 WORDS, USE SEPARATE SHEET) INDICATING WHY THE NOMINEE SHOULD BE SELECTED AS AN AWS FELLOW ACCOMPANY NOMINATION PACKET. IF NOMINEE IS SELECTED, THIS STATEMENT MAY BE INCORPORATED WITHIN THE CITATION CERTIFICATE.

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SUBMITTED BY: PROPOSER______________________AWS Member No.______________________

Print Name______________________

The Proposer will serve as the contact if the Selection Committee requires further information. Signatures on this nominating form, or supporting letters from each nominator, are required from four AWS members in addition to the Proposer. Signatures may be acquired by photocopying the original and transmitting to each nominating member. Once the signatures are secured, the total package should be submitted.

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Print Name______________________Print Name______________________

AWS Member No.______________________AWS Member No.______________________

NOMINATING MEMBER:______________________NOMINATING MEMBER:______________________

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**Q**: In a previous column, you stated that there is the potential for unique fracture modes when evaluating the quality of spot welds in advanced high-strength steels. Please clarify what you meant by this statement.

**A**: The answer to this question requires that we review and understand the prevailing wisdom of those associated with resistance spot welding (RSW) as it pertained to weld integrity before the advent of the IISI GP-3 and GP-4 steels (see Table 1), also called the advanced high-strength steels (AHSS). From a quality and engineering perspective, it was understood that it was desirable to achieve a button during the destructive evaluation of a resistance spot weld. It was believed the presence of an adequately sized button was evidence of the weld’s ability to provide the necessary engineering properties (strength, energy absorption, etc.) for the application. The definition of “adequately sized” varied from manufacturer to manufacturer, but all agreed that weld buttons were necessary.

There were also other benefits to weld buttons. From a quality perspective they offered, within the limits of operator repeatability/reproducibility, an objective method of determining the quality of a weld. An additional benefit was that the weld button size could be tracked and trended over time, and thus the quality of the weld could be used in a proactive manner to gauge, and if necessary, improve process robustness.

However, the need to use stronger materials, such as high-strength, low-alloy (HSLA) steels, in ever-stiffer sections, started to have an impact on the ability of the destructive evaluation to consistently produce weld buttons. One approach to rectifying this issue and ensuring that buttons were produced was to increase the required minimum weld size. This idea was supported from both the inspection and the design communities (Ref. 1) who felt that larger welds were needed in order to take full advantage of the stronger material properties. However, there are constraints that limit, from a practical standpoint, how large a weld can be economically produced. Also, it becomes apparent that an increase in weld size can quickly reach a point of diminishing returns with regard to an increase in mechanical properties (strength, etc.).

Since the conventional wisdom, based on tests of IISI GP-1 steels, held that adequate strength was provided by welds that produced a full button in excess of the required minimum weld size, it stands to reason that anyone associated with resistance spot welding did not hold welds exhibiting other fracture modes (i.e., interfacial fracture, etc.) as acceptable. The challenge to this line of reasoning came in the form of increasing tensile strength requirements.

![Fig. 1 — A compilation of the eight different fracture modes as detailed in AWS D8.1M:2007.](image)

<table>
<thead>
<tr>
<th>Group</th>
<th>1. Low Strength</th>
<th>2. Intermediate Strength</th>
<th>3. High Strength</th>
<th>4. Ultrahigh Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength (MPa)</td>
<td>&lt; 350</td>
<td>350–500</td>
<td>&gt; 500–800</td>
<td>&gt; 800</td>
</tr>
<tr>
<td>Typical Materials</td>
<td>Mild 140YS/270TS</td>
<td>BH 260YS/370TS</td>
<td>DP 350YS/600TS</td>
<td>DP 700YS/1000TS</td>
</tr>
<tr>
<td></td>
<td>BH 180YS/300TS</td>
<td>HSLA 280YS/350TS</td>
<td>TRIP 350YS/600TS</td>
<td>MS 950YS/1200TS</td>
</tr>
<tr>
<td></td>
<td>BH 210YS/320TS</td>
<td>HSLA 350YS/450TS</td>
<td>DP 500YS/800TS</td>
<td>MS 1150YS/1400TS</td>
</tr>
<tr>
<td></td>
<td>BH 240YS/340TS</td>
<td>DP 300YS/500TS</td>
<td>TRIP 500YS/800TS</td>
<td>MS 1250YS/1520TS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CP 700YS/800TS</td>
<td>TRIP 700YS/1000TS</td>
<td>HS 950YS/1300TS</td>
</tr>
</tbody>
</table>

(a) BH: bake hardenable; HSLA: high strength, low alloy; DP: dual phase; TRIP: transformation-induced plasticity; MS: martensitic; CP: complex phase; YS: yield strength; TS: tensile strength.

Note: Steels with a minimum tensile strength above 500 MPa (Groups 3 and 4) are generally considered advanced high-strength steels (AHSS).

spot welds that required substantial force to separate and produced significant material distortion, but resulted in the formation of an interfacial fracture or other previously undesirable fracture modes. Despite evidence that substantial strength could be achieved by a resistance spot weld that did not produce a weld button, it was not until AHSS came on the scene that a shift in thinking would occur.

The initial motivation to investigate the different fracture modes further was feedback from the manufacturing facilities. The hardworking folks on the shop floor were being confronted with unique situations and sought help from their corporate engineering organizations. At this point in time, each original equipment manufacturer (OEM) began addressing the issue. Among the many concerns for each OEM was the ability to maintain the strength and inspectability of the welds they were producing.

The welding community as a whole began to come to grips with the issue of understanding the fracture modes by way of standards committee meetings within the American Welding Society (AWS) and Auto/Steel Partnership (A/SP). The A/SP (www.a-sp.org) is a consortium consisting of Chrysler, Ford Motor Co., General Motors Corp., and six major steel producers: AK Steel Corp., ArcelorMittal Dofasco USA, Nucor Corp., Severstal North America, and United States Steel Corp.

These committee meetings brought to light the fact that the concerns were widespread within the industry and that each OEM approached the issue of the fracture modes in resistance spot welding from a slightly different perspective. The reality was despite the variations in their solutions, they were addressing a common concern. Specifically, does a satisfactory resistance spot weld require a button, and if not, what is needed in its place as evidence of an acceptable weld?

The approach taken to address these issues was at times laborious and required the hard work and dedication of professionals from many facets of the welding community, including manufacturing, supply base, and research. A summary of their efforts includes the identification of eight distinct fracture modes (Fig. 1), and establishing three critical elements that should be characterized to determine the disposition of the resistance spot weld: fused area, base metal deformation, and aspect ratio. All of the aforementioned items have been chronicled in AWS D8.1M:2007, Specification for Automotive Weld Quality — Resistance Spot Welding of Steel (Ref. 2).

The widespread use of AHSS brought to the fore the idea that there may be more than one way to view the quality of a resistance spot weld. Just as AHSSs achieve their unique properties from different methods than the more conventional grades of steel, so too must the welding community view its final product from a different viewpoint when welding on these unique materials. Another way to think of this is to look at the transition that occurred when tires shifted from bias-ply to radial construction; those who failed to comprehend that a paradigm shift had occurred found themselves trying to apply techniques that did not always dovetail with the materials they were working with.

**Acknowledgment**

The author would like to thank Jim Dolfi, former AWS Detroit Section, DSD, and ASP Joining Committee chair for his invaluable perspective on the history of fracture modes.

**References**


DONALD F. MAATZ JR. is laboratory manager, RoMan Engineering Services. He is a member of the AWS Detroit Section Executive Committee, serves on the D8 and DSD Automotive Welding committees, and is vice chairman of the Certified Resistance Welding Technician working group and the RWMA Technical committee. He is a graduate of The Ohio State University with a BS in Welding Engineering. This article would not have been possible were it not for the assistance of members of the RoMan team. Send your comments/questions to Maatz at dmaatz@romaneng.com, or to Donald Maatz, c/o Welding Journal, 550 NW LeJeune Rd., Miami, FL 33126.
Reader Disputes Details in GMAW Article

This letter regards the article “Argon/Oxygen Shielding Gases Improve Carbon Steel GMAW” by Scott Laymon, Craig Chritz, and Fred Schweighardt published in the March 2010 Welding Journal (pages 40–43). The authors’ response follows.

I respectfully disagree with many points the authors brought up.

1. In Fig. 2 of this article, a pie chart shows the typical breakdown of welding costs, yet the authors’ own cost analysis in Fig. 4 is much different. Figure 4 more closely resembles the “pie” chart of welding costs.

2. Figure 4 states that the 0.035 wire feed speed when using an Ar/CO₂ mix is 37.39 ft/min (or 488 in./min), yet the argon/oxygen mix wire feed speed is 43.29 ft/min (or 519 in./min). Does this mean that 0.035 wire cannot be used at higher wire feed speeds?

Also, Fig. 4 does not list the percent-

age of CO₂ in argon used for this test, but I would suspect that at the voltage used (26 V) the result was a weld with a good deal of weld spatter. The article does not list the material thickness for the loader arm assembly, but with the correct parameters, spatter-free welds can be produced with Ar/CO₂.

3. The article mentions that the mechanical properties of the weld with argon/oxygen are in excess of code requirements, yet they do not mention doing a macro etch of these welds. If they had done so, they would notice that argon/oxygen produces minimal penetration at best and is not suitable for the 1-in. thickness listed in the mechanical properties in Fig. 5. Argon/oxygen would be the last mix I would recommend to a customer who is welding 1-in. steel. A combination of argon in the 83–88% range with the balance CO₂ is much more suited for this thickness.

4. Argon/oxygen is a low-energy, highly oxidizing gas mix. One of the main purposes of a shielding gas is to protect it from the surrounding atmosphere, which is roughly 79% nitrogen and 20% oxygen. Why introduce oxygen to the weld pool via the shielding gas?

5. On certain applications, I will recommend argon/oxygen to customers, such as for thin materials to be welded in the flat position and the customer desires fast travel speeds. Many companies that use argon/oxygen for steels thicker than ⅛ in. feel that they are getting great weld fusion, as this mix does run hot, but a macro etch will reveal weld penetration is not as good as Ar/CO₂ mixes.

The authors’ response:

1. The percentage is a typical average and may vary slightly according to a given set of circumstances. Figure 2 is intended to be a general representation of the relative scale of each segment of weld cost.

2. It does not mean that 0.035 wire cannot be used at higher wire feed speeds. This was a comparison done using the customer’s current mix and settings compared to an argon/oxygen mix at optimized settings. The voltage used was the same for both mixes, only the amperage/wire feed was increased. The same wire feed speed could have been used for the argon and a CO₂ blend, but the voltage would have to be increased due to a decrease in arc stability. This simply shows that welding speeds can be increased at a given voltage due to an increase in arc sta-

bility at a given voltage, and not a decrease in arc stability. Pool fluidity is also increased with the argon and oxygen.

We never stated that spatter-free welds could not be achieved with the argon and CO₂ blend. As for the 26 V and weld spatter, if you are using, for example, a 10% CO₂ blend with a 0.035-in. wire, you can achieve spray transfer at 26 V; which would result in very low or nonexistent spatter. Spray transfer can be achieved at 24 V with a 5% oxygen blend and a 0.035-in. wire.

3. For the heavier materials, the CO₂ blend does a better job, and it’s what we recommend as well. However, acceptable weld penetration and mechanical properties can be achieved on thicker materials when using spray transfer. We never recommend short circuit transfer using argon and oxygen on materials greater than ½ in. thick. This specific test that the mechanical properties were derived from was done using spray transfer, with a 0.045-in. wire, on 1-in.-thick material. The joint design was a single-V-groove weld with a backing strip (⅛ in.). The base material was mild steel. The article was not intended to say that argon and oxygen is the best recommendation for all applications, material thicknesses, and joint designs. We look at these on an individual basis and make a recommendation accordingly. There are many times we recommend a CO₂ blend and sometimes an oxygen blend will work better. It is all about the individual application, and there are inherent advantages to both types of shielding gas blends.

4. As for oxidizing, a CO₂ blend is also oxidizing. When CO₂ dissociates under the arc, free molecules of O₂ are present. The oxygen’s role is to relieve surface tension in the weld pool. The silicon and manganese found in the filler metals take care of the excess oxygen and also act to relieve surface tension in the process as well.

5. In spray transfer, which is the only way we would recommend this mix on materials greater than 1 in. thick, they will get acceptable fusion and penetration. Having said that, spray transfer cannot be used out of position, so if that were the case, we would be recommending a CO₂ blend with a short circuit transfer. As for the penetration profiles, they will be different than the profiles resulting from a CO₂ mix. This difference is primarily the width just below the surface and not necessarily the depth. The increased width is a result of the dissociation and recombination of the CO₂, which creates some additional energy on the surface.

Scott Laymon, Craig Chritz, and Fred Schweighardt
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Q: We have been making an assortment of sheet metal fabrications by resistance welding 304L and 316L stainless steel for many years. Recently, it has been proposed to substitute a duplex stainless steel, LDX 2101®. But I have heard that duplex stainless steels are not suitable for resistance welding. Is this true?

A: Duplex stainless steels present a challenge for resistance welding because of the very rapid cooling rates normally associated with the process. Very rapid cooling tends to retain to room temperature most of the ferrite that forms during solidification. Further, chromium nitrides tend to precipitate in the ferrite if nitrogen does not have time to diffuse to austenite. The nearly 100% ferrite tends to make the welds relatively brittle, and the chromium nitrides can be very detrimental to corrosion resistance.

This is not to say that resistance welding is totally unusable for duplex stainless steels, only that required weld properties need to be carefully evaluated. In 1994, I coauthored a review paper on welding processes for duplex stainless steels (Ref. 1) presented at the Fourth International Conference on Duplex Stainless Steels, held in Glasgow, Scotland. In it, I noted that, at that time, resistance welding and other welding processes with inherently rapid cooling rates such as laser beam welding and electron beam welding had to be considered immature processes for duplex stainless steels. However, duplex stainless steels have evolved considerably since that time, particularly in the direction of higher nitrogen content, which promotes more rapid formation of austenite so that some austenite can be formed, especially in lean alloys, under conditions of rapid cooling. And, in particular, the very lean alloy LDX 2101® (UNS S32101) did not exist at that time. I will refer to this alloy as 2101 for brevity from this point forward.

Table 1 lists the composition ranges of 2101 and two older duplex stainless steels, 2304 and 2205, as found in the ASTM A240 standard for stainless steel plate, sheet, and strip. Of these, 2205 is probably the most common of the duplex stainless steels today. It should be noted that two composition ranges are given for 2205, the older UNS S31803 (before year 2000) and the current UNS S32205. It can be noted from Table 1 that 2101 is lower in chromium content than 2304 or 2205, lower in molybdenum content than 2205, and higher in nitrogen content than either 2304 or 2205. It can also be noted that 2101 is considerably higher in manganese content than the other alloys, which enhances its solubility for nitrogen. As a result of all these factors, 2101 has the ability to form austenite more quickly than the older alloys.

I am indebted to Alexander Thulin, research engineer at the Avesta Research Centre of Outokumpu Stainless AB, Sweden, for the information and microstructures that follow. In his as yet unpublished work, he examines resistance welding of duplex stainless steels and the use of the resistance welding machine to perform a very brief postweld heat treatment (PWHT) immediately after the welding cycle in order to try to increase the amount of austenite and decrease the chromium nitrides in the resistance welds. He also informed me that both 2304 and 2101 duplex stainless steels are today being successfully applied after resistance welding.

Figure 1 shows the ferrite contents of re-

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Table 1 — Composition Ranges of 2304, 2205, and 2101 Duplex Stainless Steels

<table>
<thead>
<tr>
<th>Common Name</th>
<th>UNS Number</th>
<th>C (wt-%)</th>
<th>Mn (wt-%)</th>
<th>P (wt-%)</th>
<th>S (wt-%)</th>
<th>Si (wt-%)</th>
<th>Cr (wt-%)</th>
<th>Ni (wt-%)</th>
<th>Mo (wt-%)</th>
<th>Cu (wt-%)</th>
<th>Mn (wt-%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2304</td>
<td>S32304</td>
<td>0.030</td>
<td>2.50</td>
<td>0.040</td>
<td>0.030</td>
<td>1.00</td>
<td>21.5</td>
<td>3.0</td>
<td>0.05</td>
<td>0.05</td>
<td>0.60</td>
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<tr>
<td>Former 2205</td>
<td>S31803</td>
<td>0.030</td>
<td>2.00</td>
<td>0.030</td>
<td>0.020</td>
<td>1.00</td>
<td>21.0</td>
<td>4.5</td>
<td>2.5</td>
<td>—</td>
<td>0.08</td>
</tr>
<tr>
<td>Current 2205</td>
<td>S32205</td>
<td>0.030</td>
<td>2.00</td>
<td>0.030</td>
<td>0.020</td>
<td>1.00</td>
<td>22.0</td>
<td>4.5</td>
<td>3.0</td>
<td>—</td>
<td>0.14</td>
</tr>
<tr>
<td>2101</td>
<td>S32101</td>
<td>0.040</td>
<td>4.0</td>
<td>0.040</td>
<td>0.030</td>
<td>1.00</td>
<td>21.0</td>
<td>1.35</td>
<td>0.10</td>
<td>0.10</td>
<td>0.20</td>
</tr>
</tbody>
</table>

---

Fig. 1 — Ferrite content of 2205, 2304, and 2101 as-welded and after short PWHT on the resistance welding machine.
Resistance spot welds in 2-mm (0.079-in.) 2304, 2205, and 2101 as-welded and after PWHT on the resistance welding machine. The ferrite is measured by metallographic image analysis. It can be seen that, in the as-welded (single pulse) condition, the 2205 and 2304 welds contain about 95% ferrite (or only about 5% austenite) while the higher-nitrogen 2101 welds contain nearly 20% austenite. In all cases, the welding current was applied for 300 ms. For PWHT on the resistance welding machine, a 200 ms delay after the weld cycle was followed by the PWHT current (lower than the welding current) applied for 2 s. This PWHT is much too short to produce any sigma phase formation in these three alloys.

The result of the PWHT cycles can be seen in the reduction of the ferrite content to about 90% (10% austenite) for the 2205 and 2304 alloys. But the ferrite content of the higher-nitrogen 2101 alloy was reduced to about 75% (25% austenite). The higher austenite in the 2101 welds is more favorable from the point of view of weld ductility and corrosion resistance. Figure 2 compares the as-welded and PWHT microstructures of the 2205 and 2101. In this figure, the light etching portion of the microstructure is austenite, and the dark etching portion is ferrite, with chromium nitride precipitation in the darkest areas. It can easily be seen that the darkest areas of chromium nitride precipitation are much smaller and more scattered in the 2101 weld after PWHT.

It should be pointed out that, in all cases, a peel test of the resistance spot welds resulted in tearing out of the weld nugget, which is normally considered a successful test. So the very-high ferrite contents in the as-welded condition are not necessarily detrimental to the mechanical performance of the welds. However, the corrosion resistance of the spot welds is of concern when there is extensive chromium nitride precipitation. Postweld heat treatment of resistance spot welds on the resistance welding machine offers a means of significantly lessening the presence of chromium nitrides in the 2101 alloy. Pickling can be used to improve the corrosion resistance of resistance spot welds, but it should be recognized that a resistance spot weld always has a crevice around it. If 304L is providing satisfactory service with a crevice, 2101 is likely to do so also.

From this it can be concluded that usable resistance spot welds can indeed be made at least in 2101 duplex stainless steel. It is important, in any such application, to evaluate the mechanical property and corrosion resistance requirements for the weldment vs. the properties provided by the weldment.

Reference

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 ASD Subcommittee on Stainless Steel Filler Metals, and the AWS DIK 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-Based Alloys. E-mail your questions to Dr. Kotecki at damian@damiankotecki.com, or send to Damian Kotecki, c/o Welding Journal, 550 NW LeJeune Rd., Miami, FL 33126.

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SPARK — How Old-Fashioned Values Drive a Twenty-First Century Corporation: Lessons from Lincoln Electric’s Unique Guaranteed Employment Program, by Frank Koller, is 6 ⅞ x 9 ⅞ in. with 249 pages. Published by PublicAffairs/New York, a member of the Perseus Books Group, (800) 343-4499. This copyright 2010 edition has seven chapters, an index, and no figures. ISBN 978-1-58648-795-9. Price is $25.95 U.S./$32.95 Canadian.

The author, Frank Koller, who was affiliated with the Canadian Broadcasting Corp., was given unique permission to interview members of Lincoln Electric’s management as well as workers. This gave him insight as to how Lincoln Electric’s system functioned. Koller is a graduate of Massachusetts Institute of Technology, with a degree in engineering.

In the preface, Koller describes the history of how Lincoln Electric was founded and developed its present business philosophy. He places emphasis on its “guaranteed employment (no layoffs)” for its permanent employees. He also describes its bonus system, which is paid at year end. The bonus is typically between 60 and 100% of a worker’s base wage. In 2008, the average bonus was $28,873.

Chapter one tells how the company was founded by John C. Lincoln, how its products changed over the years, and how its management began to develop. It was during the early years in Cleveland that John hired his brother James to manage the day-to-day operations, so that he could devote his own energies to technical matters. It was through the influence of their father’s Christian ministry that both men were guided in their management principles “to treat workers as we would like to be treated.” The remainder of the chapter deals with the labor and management conflicts of the 1920s and 1930s.

Chapters two through four describe how the company bonus system was developed and implemented. They also tell of the establishment of “The Advisory Board,” “The Open Door Policy,” and how the “piecework” compensation policy functions, as well as the “merit based bonus.”

In addition, they tell how “the guaranteed employment...depends on...understanding what the end game is all about.” And that “the END GAME is to ensure continuous profitability...in an exceedingly competitive global marketplace.” It should be noted that the guaranteed employment feature does not apply to the international employees.

Using the guaranteed employment feature as a literary tool, the author expounds in depth on his views of general labor problems, policies, procedures, and labor unions. He discusses labor, management, unions, etc., as if he is teaching a course about labor economics. An extended discussion of the Japanese management methods is included.

Chapters five and six expand on the author’s sentiment “that many, if not most, Americans believe that there is something desperately wrong with the value system of modern business” and cites sources that support the view that “...the United States has changed (to) make jobs less secure and workers more mobile.” He tells about Lincoln Electric’s approach and then delivers a sermon on what is wrong with American businesses regarding layoffs, CEO compensation, etc.

These chapters are an example of how the author uses Lincoln Electric’s unique employment policy that works for it, to expound on his own management philosophy. In his discussion of CEO salaries, he uses terms such as “bloated executive salaries,” “stratospherically high salary,” “lack of trust,” etc.

Chapter seven discusses Lincoln Electric’s approach to the 2008–2009 recession and its guaranteed employment, including a reduction in hours, pay cuts for employees, higher pay cuts for management, etc. The author includes a discussion of Hypertherm, a privately owned company, trying to have a “no layoff” policy. He then compares it to another company, Xilinx, which tried to have the same policy, but its new CEO imposed layoffs. The book ends with a discussion of how to educate management on the principles the author endorses.

Overall, Koller presents an accurate historical account of the evolution of Lincoln Electric’s unique management system. If you want to learn about Lincoln Electric’s management system, this is the book for you.

A. F. MANZ is a Fellow of the American Welding Society.
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The DLS200 scanning-spot laser sensor automates and speeds the welding of wind towers and other structures containing metal of different thicknesses. The thickness of the steel plates that form the base of a wind tower can be 50 mm or more, while the middle section is fabricated from lighter gauge metal, and near the top, the steel is thinner. The base is typically prepared with a U-joint profile, and welding takes place in several passes; the middle section requires a V-type joint and is welded in one or two passes; and steel at the top is welded with a butt joint preparation. This sensor has a programmable scan configuration, meaning a wide scan can be used for the U and V joints, but a narrow scan with high resolution can be used for the smaller butt joints. An additional feature is the stripe produced by the normal laser scan can be shrunk to a spot. By touching a button, this sensor can project the spot to measure and control the height of the welding head. Simultaneously, the operator can use the laser spot as a guide for manually controlling the horizontal position of the welding head.

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Welding Machine Suits Stainless Steel Projects

The Bulldog™ 140 portable welding machine/generator is designed for AC SMAW. It provides up to 140 A of AC welding output for arc welding on steel, stainless steel, cast iron, and hardfacing projects with up to ¼-in. covered electrodes. Plus, it includes a single, full-range calibrated welding control to dial in the ideal amperage for each project. The unit delivers up to 16.7 A continuous power from a 240V AC receptacle and up to 33.3 A continuous power from a 120V AC duplex receptacle. Its 5500-W surge AC generator can power grinders, work lights, pumps, and can be used for motor starting or standby emergency power. This machine comes with a ¾-in.-diameter tube frame that is matched with the company’s Low-Lift™ grab bars. The unit features a Subaru® 10-hp Model EX30 overhead cam gasoline engine with one-pull starting, a cast iron cylinder liner for long engine life, automatic shutdown for low oil level, and a three-year engine warranty.

The Lincoln Electric Co.
www.lincolnelectric.com
(888) 355-3213

Sensor for Wind Turbines Features POM Pinion Gear

The MR200W series yaw position transducers for wind turbine applications monitor position, direction, speed, and cable twist while providing proper feedback to the yaw directional motor drive and brake control system. They can be multifunctional and integrate any combination of geared limit switches, rotary encoders, resolvers, or potentiometers. For increased accuracy and repeatability, the unit can be supplied with an external antil backlash POM (polymer) pinion gear that optimizes coupling to the wind turbine’s large yaw bull gear.

Micronor, Inc.
www.micronor.com
(805) 499-0114

Stainless Steel Tubes Resist Severe Environments

Type 316 stainless steel cap rail is offered in 1.660- and 1.900-in. outside diameters. These stainless steel tube sections have no visible seam, may be used with ½-in. glass, Wagnerail™ panels, or the company’s Lumenrail® LED light stick. Additionally, the rail sections are stocked in 18 ft lengths and are available with mill, satin, or polished finishes. The product is for use in severe

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environments that require a high level of resistance to corrosion, including the marine environment.

The Wagner Companies
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(888) 243-6914

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The SafAscent™ wind turbine platform for external wind turbine access suits maintenance, repair, inspection, and cleaning needs. It provides a 6½-ft modular platform with a steel wind cage stirrup adding strength and stability. Three sets of removable, padded roller systems protect the tower and blades from damage. The platform’s 500-lb capacity adds efficiency with its ability to lift two workers and tools. This kit includes the platform, hoist, and accessories to enable quick access to turbines; also, the platform and kit contents exceed OSHA, OH&S, and ANSI standards.

Safway Services, LLC
www.safway.com/wind
(800) 558-4772

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The high-nickel alloy, flux cored wire PREMIARC DW-N625 (AWS A5.34 ENiCrMo3T1-4) is for use with Alloys 625 and 825, and superaustenitic stainless steel. It generates a stable arc with little spatter and is suitable for all positions with 75%-Ar–25%-CO$_2$. This wire is recommended for a variety of welding applications including hardfacing of carbon steels or low-alloy steels and welding a variety of dissimilar metal joints.

Kobelco Welding of America, Inc.
www.kobelcowelding.com
(281) 240-5600

Machine for Wind Tower Production Cuts, Welds

The MCM 2000 reduces the time required to produce a wind tower. It is a 5-axis, portable, CNC gantry designed to cut, bevel, and weld a manway into a wind tower. Doorframe fitup time is reduced

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through its programming and simple controls. Additional highlights include cutting/beveling on flat, concave, and convex surfaces; fast and firm positioning by means of permanent magnets; efficient double-sided beveling in one operation; easy-to-use control system interface; and numerical torch angle control. Custom made versions are available. This machine's technical specifications are as follows: power supply 230–240 V and 50–60 Hz; maximum beveling angle 60 deg; maximal cutting speed up to 39.4 in./min; weight 237 lb, subject to particular configuration; manual torch ignition; magnetic holding power around 1500 k; and plasma cutting optional. Its work modes also include vertical or horizontal positions, inside tubes or vessels with a diameter above 98.4 in., flat surfaces, and outside tubes or tanks.

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www.pferdusa.com
(800) 342-9015

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The LAP series are three-phase, fan-cooled DC welding power sources designed for mechanized submerged arc or gas metal arc welding. They are designed to be used in combination with the company's A2-A6 equipment range and the A2-A6 process controllers (PEK or PEI). Plus, these welding power sources offer good welding characteristics throughout the entire current and voltage range, with good starting and reignition properties, and demonstrate good arc stability at high and low arc voltages. The welding power source can be adjusted and monitored.
from the front panel of the process controller for easy adjustment of all welding parameters. The welding current range can be extended by connecting two power sources in parallel for demanding applications. The power source is prepared for communication using most standard protocols. The power sources are ideal for production of wind power components, nuclear power vessels, heavy pipe and boilers, shipbuilding, and automotive applications.

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www.esabna.com  
(800) 372-2123

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The company’s welding tip suits a variety of robotic GMAW applications. It features a silver steel insert and alumina insulator at the end of the tip, enabling improved control over electrical contact that produces a more stable, predictable, and energy-efficient arc and an increase in the tip’s life. The design is interchangeable with existing welding tips. Other improvements include increases in the welding speed, productivity gains, equivalent reductions in gas fumes and carbon emissions, a reduction of wire usage depending on applications, and spatter is almost eliminated.

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The Series 4900 Ironferno, an iron powder torch and dispenser, is a specialized version of standard oxyfuel gas equipment. The addition of iron powder into the preheat flame produces an extremely hot flame, enabling the operator to cut metals that were previously difficult or impossible. The powder torch allows for cutting in any weather condition.

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A line of SDS rotary hammers offers a lightweight, compact package. The D25023K D-handle grip ¾ in. SDS rotary hammer features a 6.9-A motor that delivers 0–1550 rev/min. This model also includes a hard-hitting hammering mechanism that offers 1.8 ft/lb of impact energy for fast drilling and powerful chipping. The D25012K pistol grip ¾ in. SDS rotary hammer features a 6.0-A motor that delivers 0–1550 rev/min. The D25023K comes equipped with a three-mode selector that can be adjusted for use in rotary hammer, hammer only, and rotary only applications, while the D25012K features a two-mode selector for use in rotary hammer and rotary only modes.

DEWALT
www.dewalt.com
(800) 433-9258

For info go to www.aws.org/ad-index
Friends and Colleagues:

The American Welding Society established the honor of Counselor to recognize individual members for a career of distinguished organizational leadership that has enhanced the image and impact of the welding industry. Election as a Counselor shall be based on an individual’s career of outstanding accomplishment.

To be eligible for appointment, an individual shall have demonstrated his or her leadership in the welding industry by one or more of the following:

• Leadership of or within an organization that has made a substantial contribution to the welding industry. The individual’s organization shall have shown an ongoing commitment to the industry, as evidenced by support of participation of its employees in industry activities.

• Leadership of or within an organization that has made a substantial contribution to training and vocational education in the welding industry. The individual’s organization shall have shown an ongoing commitment to the industry, as evidenced by support of participation of its employee in industry activities.

For specifics on the nomination requirements, please contact Wendy Sue Reeve at AWS headquarters in Miami, or simply follow the instructions on the Counselor nomination form in this issue of the Welding Journal. The deadline for submission is July 1, 2010. The committee looks forward to receiving these nominations for 2011 consideration.

Sincerely,

Alfred F. Fleury
Chair, Counselor Selection Committee
American Welding Society

Nomination of AWS Counselor

I. HISTORY AND BACKGROUND

In 1999, the American Welding Society established the honor of Counselor to recognize individual members for a career of distinguished organizational leadership that has enhanced the image and impact of the welding industry. Election as a Counselor shall be based on an individual’s career of outstanding accomplishment.

To be eligible for appointment, an individual shall have demonstrated his or her leadership in the welding industry by one or more of the following:

- Leadership of or within an organization that has made a substantial contribution to the welding industry. (The individual’s organization shall have shown an ongoing commitment to the industry, as evidenced by support of participation of its employees in industry activities such as AWS, IIW, WRC, SkillsUSA, NEMA, NSRP SP7 or other similar groups.)
- Leadership of or within an organization that has made substantial contribution to training and vocational education in the welding industry. (The individual’s organization shall have shown an ongoing commitment to the industry, as evidenced by support of participation of its employees in industry activities such as AWS, IIW, WRC, SkillsUSA, NEMA, NSRP SP7 or other similar groups.)

II. RULES

A. Candidates for Counselor shall have at least 10 years of membership in AWS.
B. Each candidate for Counselor shall be nominated by at least five members of the Society.
C. Nominations shall be submitted on the official form available from AWS headquarters.
D. Nominations must be submitted to AWS headquarters no later than July 1 of the year prior to that in which the award is to be presented.
E. Nominations shall remain valid for three years.
F. All information on nominees will be held in strict confidence.
G. Candidates who have been elected as Fellows of AWS shall not be eligible for election as Counselors. Candidates may not be nominated for both of these awards at the same time.

III. NUMBER OF COUNSELORS TO BE SELECTED

Maximum of 10 Counselors selected each year.

Return completed Counselor nomination package to:

Wendy S. Reeve
American Welding Society
Senior Manager
Award Programs and Administrative Support
550 N.W. Lejeune Road
Miami, FL 33126
Telephone: 800-443-9353, extension 293

SUBMISSION DEADLINE: July 1, 2010
CLASS OF 2011

COUNSELOR NOMINATION FORM

DATE__________________________ NAME OF CANDIDATE ____________________________

AWS MEMBER NO. ____________________ YEARS OF AWS MEMBERSHIP ____________________________

HOME ADDRESS ____________________________

CITY________________________ STATE __________ ZIP CODE __________ PHONE __________________

PRESENT COMPANY/INSTITUTION AFFILIATION ____________________________

TITLE/POSITION ____________________________

BUSINESS ADDRESS ____________________________

CITY________________________ STATE __________ ZIP CODE __________ PHONE __________________

ACADEMIC BACKGROUND, AS APPLICABLE:

INSTITUTION ____________________________

MAJOR & MINOR ____________________________

DEGREES OR CERTIFICATES/YEAR ____________________________

LICENSED PROFESSIONAL ENGINEER: YES NO STATE ____________________________

SIGNIFICANT WORK EXPERIENCE:

COMPANY/CITY/STATE ____________________________

POSITION ____________________________ YEARS ____________________________

COMPANY/CITY/STATE ____________________________

POSITION ____________________________ YEARS ____________________________

SUMMARIZE MAJOR CONTRIBUTIONS IN THESE POSITIONS:

__________________________________________________

IT IS MANDATORY THAT A CITATION (50 TO 100 WORDS, USE SEPARATE SHEET) INDICATING WHY THE NOMINEE SHOULD BE SELECTED AS AN AWS COUNSELOR ACCOMPANY THE NOMINATION PACKET. IF NOMINEE IS SELECTED, THIS STATEMENT MAY BE INCORPORATED WITHIN THE CITATION CERTIFICATE.

**MOST IMPORTANT**

The Counselor Selection Committee criteria are strongly based on and extracted from the categories identified below. All information and support material provided by the candidate's Counselor Proposer, Nominating Members and peers are considered.

SUBMITTED BY:

PROPOSER ____________________________

AWS Member No. ____________________________

The proposer will serve as the contact if the Selection Committee requires further information. The proposer is encouraged to include a detailed biography of the candidate and letters of recommendation from individuals describing the specific accomplishments of the candidate. Signatures on this nominating form, or supporting letters from each nominator, are required from four AWS members in addition to the proposer. Signatures may be acquired by photocopying the original and transmitting to each nominating member. Once the signatures are secured, the total package should be submitted.

NOMINATING MEMBER: ____________________________ Print Name ____________________________

AWS Member No. ____________________________

NOMINATING MEMBER: ____________________________ Print Name ____________________________

AWS Member No. ____________________________

NOMINATING MEMBER: ____________________________ Print Name ____________________________

AWS Member No. ____________________________

NOMINATING MEMBER: ____________________________ Print Name ____________________________

AWS Member No. ____________________________

SUBMISSION DEADLINE JULY 1, 2010
POLIFAN®-CURVE Gives You A Big Edge on Fillet Weld Finishing

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Here’s a totally new flap disc that has fillet weld finishing covered all the way around. It not only grinds from here, but from here. You get faster, easier grinding with a level of precision not possible before. It brings a whole new meaning to working on the edge.

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POLIFAN®-CURVE flaps are actually layered around and over the entire circumference of the disc, giving it a complete, circular grinding edge. It fits into fillet welds comfortably and grinds aggressively. Jobs are finished with less effort and more precision.

PERFECT PITCH
You might say this CURVE is the perfect pitch because it works so effectively. You can see a demo video on our website but you’ll want to see it live to believe it. Your local PFERD distributor can arrange that. Call him today or contact us at solutions@pferdusa.com and we’ll set it up. See how POLIFAN®-CURVE gives you the edge in solving tricky fillet welds.

For Info go to www.aws.org/ad-index

PFERD INC.
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Leominster, MA 01453
800-342-9015
fax (978) 840-6421
www.pferdusa.com
The 56,000-ton bulk carrier Sophia D was severely damaged when it ran aground off the coast of Brazil.

A Most Challenging Project: Repair of the Sophia D

BY UWE W. ASCHMEIER AND KEVIN S. PETERS

When most North Americans think of Curacao, they think of it as a tropical island oasis, a place where they get away from the everyday stress at work. But for 130 days, a group of dedicated commercial divers, welders, inspectors, and engineers called it their workplace. It was the site for a job that demanded they work seven days a week, 12 to 14 hours per day, with one day off during the entire job; a job so challenging that part of it was filmed for the television show “The World’s Toughest Fixes,” which aired on the National Geographic Channel.

The Ship’s Accident

On January 21, 2009, the 56,000-ton bulk carrier Sophia D was en route to China, loaded with thousands of tons of iron ore. Off the coast of Brazil, the ship ran aground, damaging the rudder so severely that the vessel was dead in the water, unable to be steered, stranding the 22-member crew for several weeks. At the time of the accident, the 623-ft-long freighter was less than a year old.

Miami Diver, Inc., President Kevin Peters was asked to develop a repair procedure for the damaged components. The vessel’s owner and the insurer accepted the company’s proposal to perform the repair of the rudder, the rudder horn, and...
When a cargo ship ran aground, damaging its massive rudder, a crew of commercial divers, welders, inspectors, and engineers got to work on this tough repair.

other affected components afloat. The proposal specified the repair would take place in Curacao, where Miami Diver has a fully equipped facility.

Repairs could not be performed where the vessel was stranded because of the location, which was several miles offshore, as well as poor weather conditions. In fact, the extent of the damage done to the vessel when it ran aground could not be determined on site.

The vessel was towed (Fig. 1) to Curacao, Netherlands Antilles, in the Caribbean Sea, just off the coast of Venezuela. It took 28 days to tow the vessel the 1000 miles from Brazil to Curacao.

The Proposed Repair

The proposal for performing the repairs included the following:

- Divers removing the rudder blade underwater.
- Transferring the weight of the rudder from air chain hoists to lift bags and using two of the ship’s 35-ton cranes to load the rudder blade onto the barge.
- Building and installing a cofferdam around the rudder horn in order to perform the repairs in the dry.
- Moving the cargo from the aft to the forward holds, which would allow the cofferdam to be trimmed 3 ft above the waterline.
- Dewatering the cofferdam to enable the evaluation of the damage to the rudder horn and the aft peak tank. At the same time, the rudder was to be transported by barge to the shipyard in Curacao for evaluation of the damage.
- Qualifying and certifying the welding procedures and welders to be able to weld on 1.75-in.-thick, high-tensile-strength steel. The repairs to the rudder horn and other damaged components could not be performed until the qualifications were completed.
- Cutting the rudder horn free from the hull and installing an 8-in. insert plate to remove the “dog leg” so that the pintle bushing could be realigned with the upper neck bushing.
- Cutting out and replacing the damaged shell plating on the ship hull, as well as damaged frames and the longitudinal in the aft peak tank.
- Cutting out and renewing the external rudder plating as well as replacing internal frames that were bent. After finalizing the repair to the internal frames and the skin plate, the upper and lower casting for the rudder stock and pintle had to be line bored.
- Removing the cofferdam after the repairs to the rudder horn and shell plating were complete, then reinstalling the rudder and rudder stock.
- Renewing the steering motor foundation and remounting the steering gear to the rudder stock.
- Conducting sea trials.

Removal of the Rudder Blade

The first step was to remove the 50-ton, 30-ft-tall rudder underwater.

Divers from Miami Diver, Parker Diving, All Sea Enterprises, and Trident Diving welded 1-in.-thick, 25-ton rigging pad eyes with ¼-in. fillet welds to connect the air hoists underwater onto the rudder and above the waterline to the ship’s hull. All underwater wet welding was performed with the shielded metal arc welding (SMAW) process, using Hydroweld FS electrodes, by diver-welders qualified to the requirements of AWS D3.6M:1999, Specification for Underwater Welding. The divers installed four 25-ton air hoists — Fig. 2.
The divers also had to remove the access plates to the rudder stock hydraulic nut. The underwater cutting was performed utilizing the hydrocarbon arc gouging process, allowing the diver to precisely remove the 1½-in.-size weld on the access plate. The 500-lb rudder stock hydraulic nut had to be removed to allow the rudder stock to be pulled out through the main deck. However, due to the misalignment between the lower and upper bore, the rudder stock could not be moved and had to be cut apart underwater using a hydraulic diamond rope saw.

The freed rudder blade was lowered on the four air hoists and transferred aft to four 15-ton lift bags — Fig. 3. The rudder blade was towed to the backside of the ship and a preset rigging was attached to perform a two-crane pickup using two of the ship’s 35-ton cargo cranes. The rudder blade was then loaded onto the barge and brought to the shipyard.

It was the underwater removal of the rudder that was featured on the National Geographic Channel television show.
Initial Evaluation

The first evaluation of the extent of the damage revealed the following:
- Pintel shaft and rudder stock were unusable.
- Upper and lower castings on the rudder blade were misaligned.
- Steering gear foundation was severely damaged.
- Rudder horn was bent 8 in. starboard, 2 in. aft.
- Ship’s hull was fractured forward of the gusset plate.
- Forward gusset plate was damaged.
- Internal frames in the aft peak tank were damaged and fractured in the way of the rudder horn connections.
- The ship’s shell plating, internal frames, and the longitudinal member in the aft peak tank were damaged.

Rudder Blade Repair

The rudder repair was performed in the shipyard in Curacao — Fig. 4. An inspection of the rudder revealed severe damage, which included the following:
- The upper and lower castings on the rudder blade were misaligned.
- The 1.75-in-thick rudder bottom plate was bent upward to an angle of 45 deg — Fig. 5.
- The skin plates on the port and starboard side as well as the top plate were buckled.
- After those skin plates were cropped

Fig. 3 — The rudder hanging from the lift bags.
Fig. 4 — The rudder in the shipyard.
Fig. 5 — The bent rudder bottom plate.
out, internal plates were found to be buckled to a point that they needed to be cropped out and replaced.

The 1.75-in.-thick plate mounted to the bottom of the rudder was bent so badly (Fig. 5), it had to be trimmed approximately 1 in. overlapping the edge of the rudder skin before the rudder could be reinstalled onto the vessel. The plate helps with the steering of the vessel at slow speeds.

Building and Installing the Cofferdam

A marine engineer specifically designed a cofferdam for this job that would displace 130 cubic yards of water. The cofferdam was installed around the rudder horn after the rudder was removed. The approximately 15-ft-long, 13-ft-wide, and 14-ft-tall cofferdam was built out of ¾-in.-thick ASTM A36 steel, reinforced with 4 x 4 x ¾-in. angles at the bottom and the sidewalls — Fig. 6.

The 23,000-lb cofferdam was built at Miami Diver’s facilities in Curacao while the vessel was being towed from Brazil.

After the cofferdam was finished, it was transported to the vessel, lowered into the water, lifted up, and welded to the ship’s hull — Fig. 7. Once installed, 30 tons of cargo had to be moved to the forward compartments allowing the ship to trim the cofferdam 3 ft above the waterline. The cofferdam was dewatered to enable evaluation of the damage to the rudder horn and the aft peak tank.

Qualifying the Procedures and the Welders

Before any welding could be performed on the vessel, the welders had to be qualified and the welding procedure approved by Det Norske Veritas (DNV).

The tests were performed at Miami Diver’s facility in Miami, Fla. The welding engineer wrote the necessary Performance Qualification Records (PQRs). After the PQRs were qualified, five more welders were tested in Curacao, with the local DNV surveyor as witness.

In Miami, two welders welded identical procedure qualification plates, which were 1 in. thick, and 14 in. long per DNV specifications. One welder welded qualification plates according to AWS D1.1, Structural Welding Code — Steel, on 1-in.-thick material, in the 3G and 4G positions.

Time and passing the tests were crucial, since the welding procedure was the foundation for the weld repair. Preparations and test runs were performed on Sundays.

The welding procedure qualification plates were welded in the 2G (horizontal) position. The root, filler passes, and cover passes were welded, and then the root was backgouged and rewelded from the backside. The welding process was SMAW with DNV-approved ESAB Atom Arc ½-in. 7018 electrodes.

The rudder horn material was AH 36
DNV high-strength steel; the procedure qualification was performed on high-strength, low-alloy (HSLA) material, comparable to ASTM A572 Grade 50 HSLA steel.

Preheat and interpass temperatures were calculated from the chemical composition provided by mill certificates and based on ISO/TR 17844:2004, Welding — Comparison of Standardized Methods for the Avoidance of Cold Cracks.

The preheat temperature was calculated to 225°F, with a maximum interpass temperature of 400°F. Temperatures during the tests were verified with heat-indicating crayons.

The DNV surveyor witnessed the welding of the qualification tests. The welds passed the visual inspection and welding of the qualification tests. The material needed in Houston, Tex. The plates were transported by truck to Miami, then flown to Curacao.

Rudder Horn

Since the rudder horn was bent 8 in. starboard and 2 in. aft, it was cut from the vessel at approximately 12 in. below the hull penetration. An approximately 8-in.-tall section was removed. During the cutting operation, the lower, 25-ton portion of the horn was supported vertically by six 15-ton load-rated turnbuckles. For side alignment, four 10-ton chain hoists were placed forward and aft at the port and starboard sides between the hull plating and the lower casting at an approximately 30-deg angle.

The rough cut was ground smooth, and a 45-deg bevel was prepared at the upper part of the rudder horn plating. For the lower part of the joint, the 8-in.-tall plate insert needed to be prepared with a 45-deg bevel.

An 8-in.-tall plate insert was installed to remove the “dog leg” so that the pintle bushing could be realigned with the upper neck bushing.

The rudder horn nose plate was found to be cracked and had to be cropped out and replaced. The thickness of the steel for the rudder horn plating and the nose plate was 1.75 in.

Joint Preparation

The 8-in.-tall plate insert on the port and starboard sides, as well as the nose insert plate, were tacked in place and strongbacks were welded onto the backside of the joint — Fig. 8. Run-off plates were welded at the ends of the welding joints.

Joint preparation was a single bevel groove weld with a 45-deg opening angle on top. This allowed the lower part of the joint to be used as a shelf. The root opening was held at approximately ± ¼ in.

After alignment of the inserts was confirmed, ceramic heating elements and insulation pads were installed to maintain the preheat temperature and to reduce the cooling rate of the finished welds — Fig. 9. After approximately two hours the 225°F preheat temperature was achieved and the root could be welded. Preheat and minimum interpass temperatures were maintained during the welding operation for a distance not less than 3 in. in all directions from the point of welding.

The two upper joints on the port and starboard side were welded first. The root passes on the upper weld joints were welded simultaneously by two welders, each working on one side. They worked in a predetermined welding sequence, staring from the center to the outside. Four welders working at the same time, two on each side (Fig. 10), welded the fill and cover passes. Welding was accomplished in two 12-h shifts.

The welders started in the center of the joint, moving outward. The challenge was to convince the welders they weren’t in a race, and each welder had to weld at the same speed. It took 35 passes and approximately 24 hours to fill each of the 12-ft-long joints.

After welding the outsides of the insert plates and the front section, the rudder horn nose and the root sides of the welds needed to be gouged out and rewelded from the inside. This posed a burden on the welders, since they had to sit inside the rudder horn, with preheat temperatures still applied. After welding the root from the inside of the rudder horn,
the internal girder and the plates needed to be installed.

After welding was completed, the temperature was increased to 350°F, held for 2 h, then decreased 50°F every 2 h until ambient temperature was achieved.

Other welding repairs performed with regard to the rudder horn connections were internal frames in the aft peak tank, hull plate, and gusset plate forward of the rudder horn. The steering gear foundation was reconstructed and the main deck plate, which had had to be cut out to remove and reinstall the rudder stock and steering gear foundation, needed to be re-installed.

**Weld Inspection**

Mark Thury of Interternational Inspections, Inc., a third-party inspection agency based in California, performed all the inspections, including weld inspection.

Det Norske Veritas required 100% visual inspection of all welds, magnetic particle testing on root passes of all welds on insert plates, and ultrasonic inspection of all complete-joint-penetration welds — Fig. 11. In addition, leak testing had to be performed on all watertight compartments. After Thury passed the inspected items, the DNV surveyor performed a verification inspection.

**Removal of the Cofferdam**

With the completion of all repairs, divers removed the cofferdam. The rudder also had to be reinstalled (Fig. 12), as well as the rudder stock and the steering gear foundation.

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A welder uses the gas tungsten arc process to fabricate a stainless steel assembly.

Tips for Welding Stainless Steel

BY BRENT WILLIAMS

Answers are given to practical questions unique to welding austenitic stainless steels

Whether it is being used for chemical processing equipment, heat exchangers, or in food and beverage processing, austenitic stainless steel, also called 300 series stainless steel, has become an increasingly common material across multiple industries. This is due, in part, to stainless steel’s corrosion resistance and its relatively high tensile strength. It also possesses good ductility, enabling it to withstand a range of service conditions and temperatures.

However, welding austenitic stainless steel poses a number of distinct challenges. For example, the steel is a poor conductor of heat and it is also prone to thermal expansion during the welding process — both of these factors can lead to distortion and cracking. In addition, austenitic stainless steel is prone to carbide precipitation, a phenomenon that reduces the corrosion resistance of the austenitic stainless steel. These factors make gas tungsten arc (GTA) the welding process of choice (lead photo) for joining austenitic stainless steel since it creates a narrow heat-affected zone (HAZ).

With such challenges inevitably come inquiries as to the best way to GTA weld austenitic stainless steel. The most often asked questions follow.

What is carbide precipitation and how can it be prevented?

Carbide precipitation results when the chrome, which has been added to the steel to enhance its corrosion-resistance properties, combines with carbon to form chrome carbides. The carbides form at temperatures between approximately 800° and 1400°F (426° and 760°C). In addition to changing the grain structure of the weldment, carbide precipitation also lowers the material’s resistance to corrosion. Controlling the heat input and travel speeds are the key factors in preventing carbide precipitation.

To do this, first, rely on the “rule of amperages” when GTA welding austenitic stainless steel. Use 1 A of welding current for every 0.001 in. of material thickness.

Also, maintain steady travel speeds to prevent carbide precipitation. Move the torch and add the filler metal at a rate that creates a weld approximately twice the size of the tungsten electrode being used.

Good austenitic stainless steel welds are straw colored, whereas those in which carbide precipitation has occurred are black. Welds that have the potential for carbide precipitation are generally blue or purple. By considering these colors, you should be able to determine whether you are achieving the correct heat input and travel speeds when welding austenitic stainless steel.

What shielding gas should be used?

Using the correct type and amount of
shielding gas are key factors when welding austenitic stainless steel, and they are also ways to prevent carbide precipitation. As a general rule, argon is the first choice for welding this stainless steel, especially the thinner gauges. For thicker gauges, the addition of small percentages of hydrogen allow increased travel speeds. Generally speaking, austenitic stainless steel is prone to distortion due to its susceptibility to thermal expansion. This problem results from a relatively localized HAZ that, when it cools, transfers heat slowly to the surrounding metal and causes it to buckle.

How can distortion be prevented?

Generally speaking, austenitic stainless steel are proper joint design, clamping, and placement of numerous tack welds.

First, when possible, create a joint design that minimizes the number of weld passes needed to finish the joint. Doing so minimizes the overall heat input and with it, distortion. Viable options include V-groove, modified V-groove, and U- or J-groove joint designs. Clamping or fixturing the austenitic stainless steel parts during welding can also work well to prevent distortion, especially when GTA welding thinner pieces that tend to distort more easily. Finally, consider placing numerous small tack welds along the joint you are welding to further protect against distortion.

Also, be mindful of the overall travel speeds and heat input to prevent distortion.

What type filler metal is best?

The type of austenitic stainless steel to be GTA welded determines which filler rod to use. The joint design, welding application, and welding parameters are also factors in making this decision.

Whenever possible, it is best to match the filler and base material to help preserve the integrity of the welded joint compared to the base metal. For example, when welding 316 or 316L stainless steel, select 316 and 316L filler rods, respectively. In special circumstances, you may want to use a filler metal different from the base metal to emphasize a certain property or characteristic (e.g., overmatch the strength of the filler metal to the base metal). Table 1 shows various filler metal options. Austenitic stainless steel filler metals are available in diameters ranging from 0.035 to % in. (0.9 to 4.0 mm).

As a side note, you should always use a filler metal when GTA welding on austenitic stainless steels thicker than 18 gauge.

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Table 1 — Filler Metal Selection for Welding Stainless Steels

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As a side note, you should always use a filler metal when GTA welding on austenitic stainless steels thicker than 18 gauge.

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Austenitic stainless steel offers excellent benefits, including corrosion resistance and high tensile strength, making it the ideal choice for a wide variety of industrial applications.

What power sources are needed?

The best choice for welding austenitic stainless steel is a DC power source set to direct current electrode negative (DCEN).

For thinner austenitic stainless steel (16 gauge or thinner) consider using an inverter-based power supply. Inverters provide faster travel speeds that lessen the amount of heat that goes into the work-piece. Inverters also provide advanced pulsing capabilities, with higher pulse frequencies that focus the arc to create a narrower HAZ. This focused heat input also helps to reduce distortion. Using a high-frequency start also creates a narrow arc that is beneficial when welding austenitic stainless steel.

When welding austenitic stainless steel thicker than 16 gauge, a standard DC power source with a high-frequency arc start works well. You can also use the pulsing capabilities of an inverter on this thickness of material, as well.

Other questions?

Like all metals, austenitic stainless steel requires special attention during the GTA welding process. Still, despite its tendency toward distortion and the development of carbide precipitation, the benefits of using this material, especially its corrosion resistance, far exceed the challenges. And if, while welding austenitic stainless steel, you encounter other questions or problems than those answered here, there are resources to help. Consult your local welding distributor or equipment manufacturer for advice.

Reference

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Winds of Opportunity

Here's a look at where the North American wind-power fabrication industry stands today and some requirements for companies wanting to join this supply chain

BY DALE W. RECKMAN

Utility-grade wind turbine located in the central plains having routine maintenance performed on the 4th of July.

Fabrication opportunities abound within the utility-grade wind supply chain for those companies that understand what it is that they truly do well, use that insight to create their best fit within the supply chain, and then adequately control levels of both quality and competitiveness. Shortcomings in any of these areas, however, will limit their success in this highly competitive global market.

It is with this perspective in mind that the Great Lakes Wind Network (GLWN) was formed in 2007. A nonprofit organization headquartered in Ohio, GLWN aids companies in identifying their core strengths and weaknesses, finding their best possible market fits, and evaluating their quality and competitiveness against utility-grade wind supply chain requirements. No longer is the typical North American manufacturer competing with the company down the road or across town. Competition is hungry, global in nature, and may come from as far away as Asia or Europe.

People want windpower — Fig. 1. The U.S. Department of Energy forecasts double-digit growth through 2030 (Fig. 2), further reinforcing the fact that the renewable energy market, and more specifically wind, is a viable area for market diversification.

Most utility-scale wind turbine original equipment manufacturers (OEMs) have selected locations in close proximity to North America’s best wind resources. Industry-focused first-tier manufacturers, such as blade and tower facilities, have subsequently sited themselves in the same corridors, making for increased levels of logistics efficiency.

Within the utility-grade wind industry, fabrication opportunities are generally categorized as small, large, and ‘A’ drive critical. The small sector is comprised of items such as simple sheet metal guarding and bracketry as might be found in most manufacturing facilities. This type of work generally has few code-type requirements, is carbon steel, and is generally open tolerated. Large sector items will typically include larger bracketry, crane structural when not standard off-the-shelf type, towers, and in some cases, nacelle-supporting structures — Fig. 3. This work is, again, generally carbon steel. In some rare cases, aluminum and stainless steel materials are also used but much less so than the more-common carbon steels. Most work in this sector will adhere to the requirements of AWS D1.1, Structural Welding Code — Steel, or D1.2, Structural Welding Code — Aluminum, and will be subject to increased levels of nondestructive inspection both in process and upon completion. Towers typically have unique criteria they must adhere to including specialized inspection and manufacturing practices. The largest sector is commonly known as the ‘A’ drive critical components. Examples of these components are some main rear frames, front frames (when not cast configurations) and generator frames. These items can range in size up to 10 x 8 x 16 ft with weights ranging up to 20,000 lb. Items in this sector typically have significant quality requirements including portable coordinate measuring machine inspection, nondestructive inspection both in process and upon completion using dye penetrant, magnetic particle, and ultrasonic inspection techniques.

In general, manufacturers must have clean, well-organized facilities with equipment, resources, and staffing ideally structured to meet the demands of their specific sectors. Oftentimes, it is seemingly
Fig. 1 — This graph represents the actual global cumulative installed capacity of windpower through 2009.

Fig. 2 — The U.S. Dept. of Energy predicts wind power will represent 20% of U.S. capacity by 2030.

Fig. 3 — Typical utility-grade wind nacelle interior with key components identified. Examples of both large and ‘A’ drive critical items can be seen in this image.

Fig. 4 — Utility-grade, wind-capable fabrication facility. Note the level of organization. (Photo courtesy of Midland Steel, Wathena, Kan.)

Fig. 5 — Market sector-specific criteria for utility-grade wind supply chain fabrications.

Fig. 6 — Utility-grade wind nonsector-specific requirements.
insignificant details that are overlooked that can ultimately delay or even stop the OEM approval process. When preparing for the OEM qualification audit process, every aspect of one’s manufacturing facility should be reviewed. Items like legible capacity identification on crane bridges, drops lying around on manufacturing floors, and overflowing refuse containers all make a difference. In Fig. 4, note the floor organization, clean crane bridges, adequate overhead lighting, and, in general, orderly assembly area.

Utility-grade wind turbine OEMs operating in North America today include General Electric in Florida and South Carolina, Gamesa in Pennsylvania, Clipper Windpower and Acciona in Iowa, DeWind in South Carolina, and Nordic Windpower in Idaho. OEMs with plants under construction include Nordex in Arkansas, Siemens in Kansas, and Vestas in Colorado. Site selection teams for a variety of other European and Asian wind turbine manufacturers are at work across North America, evaluating wind farm locations and supply chain resources as part of their decision process.

Within the utility-grade wind supply chain, most components will be purchased by first- or second-tier suppliers, who will complete subassemblies for shipment to OEM final assembly plants. It is expected that OEMs will continue to prefer suppliers who can provide complete, ready-to-assemble systems or components over those who supply individual parts. Figures 5 and 6 show requirements for fabricators and for nonsector-specific suppliers.

ISO 9001 certification, while highly recommended, does not guarantee nor exclude an organization from joining the utility-grade wind supply chain. It may, however, limit the number or type of components a plant is authorized to manufacture. In summation regarding ISO certification, most utility-grade wind OEMs require 9001 certification for the A’ drive line critical components but can be somewhat more flexible for the less critical items. As an additional note, some OEMs are also requiring ISO 14001 certification within a specific period of time from the date discussions begin. Other quality initiatives such as LEAN, 5S and Six Sigma, while generally believed to be beneficial to the manufacturing processes, are not widely recognized as a requirement for doing business. They can, however, be good indicators to an OEM regarding a prospective manufacturer’s level of organization and competitiveness.

Utility-grade wind has not been immune to the ongoing negative economic climate. Supply chain activity is down as OEMs posture themselves for the projected increases in activity in late 2010 and 2011. In light of this, now is the time to be investigating opportunities this market affords so as to be better equipped to reap the benefits utility-grade wind manufacturing has to offer in the coming months. Much additional information can be found by visiting the following:

- Great Lakes Wind Network, www.glwn.org
- BTM Consulting, www.btm.dk
- MAKE Consulting, www.make-consulting.com
- Kansas AMI, www. amisuccess.com

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Floating Turbine Captures Wind Energy in Deep-Water Environment

Statoil has installed what it believes to be the world’s first full-scale floating windmill. Located 10 km off the island of Karmøy, north of Stavanger, Norway, the Hywind pilot project combines technology from wind as well as oil and gas industries (see lead photo). This Statoil-owned concept also draws on the company’s offshore experience. The test period began in autumn 2009 and will last for two years.

Additionally, the technical challenges in production of a moving substructure in a marine environment are representing new opportunities for an industry proficient in fabricating large welded steel structures.

From Sailing to Testing a Concept

When sailing in 2001, colleagues Dag Christensen and Knut Solberg had the idea of a floating wind turbine. Back in the office, they sketched the concept on a paper napkin and started to look into possible solutions for a floating wind turbine using existing offshore technology.

The company’s research center and technology division as well as several external engineering companies were given the task of choosing the concept and technology prior to a prime test of the Hywind.
The Hywind pilot project, currently being tested over a two-year period, withstands the heavy load of wind and waves thanks to high-quality materials and welding used in its construction

BY VERA INGUNN MOE

concept in the Norwegian Marine Laboratory during November 2005 — Fig. 1. A small model was tested there in waves and wind, which went off successfully.

Hywind Pilot Project Details

The Hywind pilot project design is based on a spar buoy concept of a slender tubular steel substructure with a draft of 100 m, a steel tower with a height of 65 m above sea level, and a wind generator on top. The structure is filled with ballast — rocks, concrete, and water — and is anchored by a three-point mooring spread.

The substructure is a welded cylindrical steel structure with a length of 117 m and a diameter of 8.3 m, which is reduced to 5 m at the interface to the tower — Fig. 2.

The wind turbine itself was built by Siemens, Statoil's partner in a cooperation project on technology to develop floating wind turbines based on the Hywind concept. Technip built the floating structure and was in charge of the offshore installation. Nexans installed the cable to shore, and Haugaland Kraft was responsible for the landfall.

Supported by a gap analysis of a standard turbine on a floating foundation vs. a piled one, only one change was decided upon. The initial modification targeted was a strengthening of the turbine by using a standard 3.6-MW tower instead of the standard 2.3-MW turbine.

Fabricating and Welding the Structure

Basic design, material quality, fabrication, and in particular, welding quality, have been decisive factors for the success of Hywind so far. It is expected to be exposed to high fatigue loads in a combination of wind and wave action. Thus, a wall thickness of up to 88 mm is necessary for the coned part of the substructure being subject to the highest fatigue loads. Also, high-strength steel grades with excellent material properties were chosen to achieve sufficient impact values for the welds down to -40°C test temperatures.

The floating structure was designed in accordance with the Det Norske Veritas standard DNV-OS-C101, Design of Offshore Steel Structures, General (LRFD method). In addition, the DNV-OS-C401, Fabrication and Testing of Offshore Structures, was applied to welding procedures, qualifications, and inspections. Fabrication was carried out by Technip at its Pori Yard in Finland in accordance with common offshore requirements for primary structures — Fig. 3. Fatigue critical details were inspected according to requirements for special structures, i.e., a 100% surface and volumetric inspection.

Why Use a Floating Turbine?

Taking wind turbines to sea presents new opportunities. The wind is stronger and steadier, and more power is produced. There is plenty of space, and the challenges known from onshore projects are fewer. With a floating wind turbine, the advantages are even larger, as deeper waters can be utilized.

Hywind was towed out just like Statoil has done in previous undertakings for its offshore oil and gas business — Figs. 6, 7. The advantages of towing a floating wind turbine offshore are obvious, as the marine operations for a piled foundation are costly.

Fundamental Questions

Ever since Hywind was launched, the concept has been met with several fundamental questions such as the following: Will Hywind float? Could the horizontal pitch lead to instability of the structure? Might the forces be too strong, so that this structure will encounter fatigue earlier than other solutions?

The Experience So Far

Since Hywind was installed in early September 2009, the structure has been closely monitored to track its operational systems and behavior. There has been considerable wind variations through the first testing period with challenging winds between 12 and 19 m/s and even up to 25 m/s combined with cold weather and big waves — Fig. 8.

The Hywind structure has done very well. Having had quite steady results, the Hywind team decided to let the structure work in a stand-alone mode without any supervision through the two weeks around New Year’s day. The winds in this period were of the most demanding type with regard to pitch behavior and thus, affecting the horizontal movements both statically and dynamically. During this period, the
A model of Hywind in the size 1:47 was tested at the Marine Laboratory of the Norwegian Technical University in Trondheim during autumn 2005 with challenging winds and waves, including a significant wave height of up to 17 m. The concept proved to be feasible. (Photo courtesy of Peder Songedal/Statoil.)

horizontal pitch was smaller than calculated in the static and dynamic models. The results proved to be similar to the results from previous tests in the marine basin laboratory.

“The results are very encouraging,” said Sjur Bratland, manager of the Hywind project. “This is actually a significant first milestone in proving the concept, as questions regarding fatigue and feasibility will relate to the horizontal pitch.”

Also, Hywind has performed well with respect to high, steady power production.

Technology Challenges

Weight is decisive in any new development of turbines for the Hywind concept because it has a direct impact on the size, draft, fatigue performance, and life expectancy of the structure. The topside hub weight and its placement in the structure, as well as access for maintenance, are regarded as the most critical factors for a commercialization of Hywind. Offshore maintenance costs are substantially greater than on land, and the industry must think anew in order to achieve good and reliable operation.
Fig. 3 — The Hywind substructure is ready for transportation at the Port Yard in Finland. (Photo courtesy of Joachim Sverdrup-Thygeson/Technip.)

Fig. 4 — Fabrication of the internal ring stiffeners for the cone sections. (Photo courtesy of Joachim Sverdrup-Thygeson/Technip.)

Fig. 5 — Welding of the mooring pad eye sections. (Photo courtesy of Joachim Sverdrup-Thygeson/Technip.)

Fig. 6 — The Hywind substructure gets towed from Finland to Norway, covering more than 1000 miles at sea. (Photo courtesy of Kim Laland/Statoil.)

Fig. 7 — The assembled Hywind travels via a tow from Åmøsfjorden close to Stavanger for the location 10 km west of Karmøy. (Photo courtesy of Øyvind Hagen/Statoil.)
**Facts about the Hywind Pilot Project**

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Direct drive and more robust permanent magnet generators represent possible ways to reduce both operational challenges and weight. The company’s approach is to encourage turbine developers to produce solutions adapted for offshore use and to test them under challenging conditions.

The two-year Hywind pilot project has just started, and any changes to the concept must go through a thorough process of conceptual development. Statoil is about to evaluate the first results for the systems and structure, and any improvements will be carefully considered and developed as potential new sites emerge. In this respect, it is a research and development project, and any conclusions on improvements must be taken after completing the current demonstration period.

**Key Project Objectives**

The primary intention is to test how wind and waves affect the structure, not to maximize energy production and derive revenues from the Hywind pilot. Once these answers have been obtained, Statoil can work on commercializing the concept. The goal is to reduce costs so that floating wind power can compete in the energy market.

The goals for the Hywind pilot project this first year are to ensure that all the systems are working well, in particular the control systems, substructure, and actual operation of the concept during as much stand-alone time as feasible for this solution in an early conceptual phase.

In addition, the company is investigating other opportunities to develop the concept commercially by looking at other possible sites, where other issues and other wind conditions may apply. Depending on the first results from the Hywind pilot project, this could imply some changes in the detailed technical solutions chosen.

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*Fig. 8 — The wind conditions for the Hywind pilot project are quite challenging, as can be seen here in a full storm with some 25 m/s winds. The horizontal pitch caused by the winds and waves was smaller than expected, but it delivered quite well. In week 11 (mid March 2010), Hywind produced at full capacity more than 50% of the time. (Photo courtesy of Octopus/Statoil.)*
The United States commercial nuclear industry appears to be on the verge of resuming construction of new nuclear power plants. This is attributable to two primary drivers, increased energy demand and greenhouse gases. It is estimated that U.S. energy needs will increase 26% by 2030 in order to satisfy projected commercial, residential, and industrial growth. Because of concern about global warming and the impact greenhouse gases may play in that process, construction of (fossil fuel) CO₂-emitting plants as a source of energy is being discouraged. Renewable energy sources, while environmentally friendly, cannot meet the demand, leaving nuclear power to fill the energy gap. For these reasons, many consider modern nuclear technology to be a viable and environmentally friendly source of energy that can help meet upcoming U.S. energy needs.

In preparation for the resurgence of commercial nuclear power plant construction, Fluor has renewed its ASME nuclear certifications of authorization/accreditation; required for nuclear facility construction. In addition, the company has reviewed its historical work practices to identify areas where improved efficiencies might be realized in project cost and schedule. One of these areas is the control and documentation of construction activities, via the work package process. In the past, this activity tended to be labor intensive and accounted for a significant part of the overall construction effort. In addition, because of the recent hiatus in U.S. nuclear construction, a shortage of trained nuclear workers exists. To improve on the “old way of doing business” and to address the current worker shortage, Fluor is developing/preparing an electronic construction work package process that will do the following:

• Require fewer trained workers.
• Improve control of construction activities by reducing the potential for human error.
• Reduce the overall time and effort associated with preparation, handling, review, and storage of paper associated with controlling and documenting construction activities.

A brief summary is presented here of the overall electronic work package process and a description of the development and qualification of a key activity within this process — an electronic welding program (Welding Module).

Electronic Work Package — System Summary

The overall work package process is referred to as the Nuclear Project Management-Information Management System (NPM-IMS). It is computer-software based and electronically performs the following three main functions:

• Captures all necessary design information needed to construct the system, structure, or component.
• Evaluates design attributes, associated with the item to be constructed, against applicable code and construction practices to identify construction requirements.
• Documents construction activities, including work requirements, completion, sign-offs, acceptance, etc.

Electronic Welding Module

Welding was the first of several construction activities (others include electrical, piping, etc.) to be addressed within the NPM-IMS system. The software prepared for each of the several activities is referred to as a module. Key subject matter experts (SME) in the areas of welding, nondestructive examination (NDE)/inspection and software automation were assembled to develop and qualify the Welding Module.

Welding Module Development

The initial activity was to define the program objectives, i.e., what tasks and associated requirements the Welding Module should perform. A review of typical activities performed by construction welding identified the following key tasks:

• Welding procedure specification (WPS): selection
• Postweld heat treatment (PWHT): determination and temperature/time
• Preheat: determination and temperature
• Backpurge: determination
• NDE for preservice examination: determination and method/extent/acceptance
• NDE for final weld examination: determination and method/extent/acceptance
• Welder qualification: qualification status and maintenance of certification

Each of the above tasks was developed and qualified separately (referred to as submodules) and together comprise the Welding Module. It should be noted that the Welding Module scope is not comprehensive, i.e., not all of the work package requirements associated with each task is generated by the submodules. For example, PWHT requirements for materials not expected to be part of the plant design were not developed. In addition, requirements requiring development of complex logic were excluded for activities performed infrequently. The development team wanted to keep this first version relatively simple to ensure successful implementation. The system, however,
can be easily modified to expand scope. In the meantime, requirements not generated by the Welding Module, can be manually entered into the work package by the field welding engineer. Figure 1 provides a flow diagram of how the module generates work package welding requirements.

**Submodule Description**

The submodules evaluate just one weld at a time in generating welding requirements. For example, to determine if PWHT is required for Weld X (and if the answer is yes, what are the temperature and time values), the submodule retrieves specific information (attributes) about Weld X from the NPM-IMS. These attributes, such as the governing code and class for the component, material type, thickness, joint design, etc., are evaluated to determine PWHT requirements for Weld X. Determination is made by processing the attributes through a series of logic lines — Fig. 2. Each logic line describes a unique set of weld attributes along with the resulting, code-specified PWHT requirements. Requirements are then written to the work package.

Submodule Development

With the “old way” of doing business, Design Engineering would specify weld attributes on a drawing, piping schedule, specification, etc. The welding engineer would evaluate this information against applicable code rules and company practices to determine welding requirements. Requirements were then annotated to the work package. The Welding Module operates in a similar fashion, except that all weld information/attributes reside within the IMS system in an electronic format. The submodule essentially performs the role of the welding engineer in processing the information, determining welding requirements, and inputting into the work package.

With regard to development, the greatest challenge encountered was the conversion of code rules (written text and tables) into discrete, simple (yes/no), and unambiguous attributes that could be processed by the module. Again, using the PWHT submodule as an example, the ASME Section III default position for PWHT is that all welds are to receive treatment, unless specifically exempted. Exemption is granted based on a variety of variables, including component class, type of joint, material thickness, chemistry, etc. The difficulty arises from the code’s use of terms that at times can be somewhat ambiguous and inconsistent in their application. For example, the term “attachment weld,” depending on the code class, can mean different things with regard to weld requirements. Use of the terms “cladding, hard surfacing, butter-
ing, or buildup” may produce the same or different welding requirements, again, depending on how the particular code book uses the term. Such nuances may not be difficult for an experienced welding engineer to correctly interpret, but can be problematic for a computer-based system.

Each of the submodules was prepared by identifying all code and company practice attributes (information needed to determine welding requirements), reducing them to simple, computer-friendly terms, and preparing sufficient logic lines to address welding conditions anticipated during construction. During the course of development, demonstration trials were conducted to gauge submodule performance. In an effort to ensure integrity of the submodules, i.e., that all code and company practices are accurately reflected in the module requirements output, a formal system for validation was developed and performed.

Welding Module Validation

As noted above, demonstration trials were conducted to assess system performance and to verify that requirements output are in compliance with the various governing codes and standards, and company construction practices. In addition, a formal validation system was established to allow the system to recognize only those welds that have been validated or preapproved. Each weld anticipated to be performed in the field will have been run through the module and when verified (by a welding engineer) to produce the correct output (PWHT, preheat, WPS, etc.), will become part of an approved database of welds.

If the system is requested to process an unverified weld, it will be flagged as “unapproved” and will require manual processing by the field welding engineer. For example, let’s assume the module is asked to process an unapproved weld calling for the use of ASME SA-53 piping material (not originally anticipated in the design). The module will provide the requested output data if all required attributes were input into the NPS-IMS system, but as noted above, an error flag will display, indicating manual processing required. In this case the field welding engineer will manually review the output data and, if correct, will approve for work package input. This “new” weld will then be validated for system use and added to the approved database of welds. If welds using ASME SA-53 piping material are subsequently required, the Welding Module will now automatically process the request and provide appropriate welding requirements to the work package.

Conclusion

Fluor believes that innovation of construction practices, such as those described in this article, will be required to successfully complete the next round of nuclear new-build plants. The NPM-IMS system is just one of several new practices the company is preparing in support of U.S. commercial nuclear power plant construction.

Acknowledgments

The authors would like to thank and recognize the following Fluor employees for their efforts and contributions to the activities described in this article: Richard Maurer, construction management; Mark Albertin and Gene Parks, construction automation; and Kevin Clark, automation engineering.
This conference will showcase some of the most promising new technologies. Heading the list will be presentations on arc welding, laser beam welding, friction stir welding, resistance welding, and heat treating, all aimed at generous improvements in productivity and quality. Many are already finding applications in various industries. Others are in line for acceptance. The keynote speaker will be Mike Russell from The Welding Institute in the UK who will discuss many of the new developments in friction stir welding. Discussing the subject from another vantage point will be Jeff Ding from NASA, Huntsville, Ala., who will cover thermal stir processing and ultrasonic stir processing. Matt Short from Edison Welding Institute will describe EWI’s efforts in ultrasonic additive manufacture. Another speaker who will address additive manufacture will be Scott Poepel from Joining Technologies. In this case the process involves the use of a laser to apply powder metal. In arc welding, presentations will be made on short-circuiting transfer GMAW and hot wire/cold wire GTAW cladding. Information about the use of fiber lasers for welding, cutting, and cladding will be presented as will some of the newer nondestructive examination technologies. Among them are phased array, computerized X-ray, and time-of-flight testing technologies. The subject of heat treating will also be of interest to the audience. One presentation will address the monitoring that takes place in the surveillance of heat treating.

The World of Energy — Welding’s Greatest Challenge
San Diego, Calif.
August 31, September 1

This conference will examine many avenues, including the important aspects of coal-powered plants, the present and future states of nuclear power, activities in pipeline construction, land-based and offshore work in liquefied natural gas (LNG), solar energy, and wind power. Metals will be emphasized, especially Grade 91 steel, 2205 and the many other duplex stainless steels, and nickel-based alloys. New welding processes are already playing major roles in this arena and cladding is becoming more important than ever. Some of the world’s largest operations, like the $10 billion, 3000-MW solar-powered facility in India and the expansive Gorgon gas fields in Australia, are expected to be on the agenda. Much of welding’s future depends on industry’s ability to adapt and promote its technologies to that cause.

New Welding Technologies — The Key to Higher Productivity
Ft. Lauderdale, Fla.
June 15, 16

This conference will showcase some of the most promising new technologies. Heading the list will be presentations on arc welding, laser beam welding, friction stir welding, resistance welding, and heat treating, all aimed at generous improvements in productivity and quality. Many are already finding applications in various industries. Others are in line for acceptance. The keynote speaker will be Mike Russell from The Welding Institute in the UK who will discuss many of the new developments in friction stir welding. Discussing the subject from another vantage point will be Jeff Ding from NASA, Huntsville, Ala., who will cover thermal stir processing and ultrasonic stir processing. Matt Short from Edison Welding Institute will describe EWI’s efforts in ultrasonic additive manufacture. Another speaker who will address additive manufacture will be Scott Poepel from Joining Technologies. In this case the process involves the use of a laser to apply powder metal. In arc welding, presentations will be made on short-circuiting transfer GMAW and hot wire/cold wire GTAW cladding. Information about the use of fiber lasers for welding, cutting, and cladding will be presented as will some of the newer nondestructive examination technologies. Among them are phased array, computerized X-ray, and time-of-flight testing technologies. The subject of heat treating will also be of interest to the audience. One presentation will address the monitoring that takes place in the surveillance of heat treating.

A panel of aluminum industry experts will survey the state of the art in aluminum welding technology and practice. Attendees will also have the opportunity to network with speakers and other participants, as well as to visit an exhibition showcasing products and services available to the aluminum welding industry.

Aluminum lends itself to a wide variety of industrial applications because of its light weight, high strength-to-weight ratio, corrosion resistance, and other attributes. However, because its chemical and physical properties are different from those of steel, welding of aluminum requires special processes, techniques, and expertise.

2010 FABTECH Conference Schedule
Atlanta, Ga.

National Welding Education Conference
November 2

What’s New in Weld Consumables?
November 2

A low-hydrogen weld deposit is obviously the result of proper use of low-hydrogen filler metals. Much has been done and is still being done in the development of low-hydrogen manual arc electrodes. It has become imperative that the relatively new Grade 91 steel be welded using low-hydrogen filler metals, and much is under way in the development of new chemistries for these electrodes. Many of the gas metal arc welding technologies also produce low-hydrogen weld deposits, as does submerged arc welding. Industry still has to learn to store these electrodes in rod ovens when not in use, a practice not always observed in fabricating plants throughout America. The main thrust here is in ASME code work, shipbuilding, off-highway equipment, and in the chemical industry and power plants. The introduction of duplex stainless steels and the higher-strength versions of same require new filler metals that answer the needs of many plants that deal with corrosion-resistant materials. The roles of heat treatment and shielding gases will also be discussed.

The Tools and Roadways to Effective Weld Repairs
November 3

New Developments in Thermal Spray Coatings, Processes, and Applications
November 3

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.

The Welding and Cutting of Pipe and Tubing
November 4

For more information, please contact the AWS Conferences and Seminars Business Unit at (800) 443-9353, ext. 462. You can also visit the Conference Department at www.aws.org/conferences for upcoming conferences and registration information.
The premier event dedicated to aluminum welding technology!

Welding aluminum requires special processes, techniques and expertise.

Join a distinguished panel of aluminum industry experts as they survey the state-of-the-art aluminum welding technology and practices at the 13th Aluminum Welding Conference and Exhibition.

For the latest conference and exhibitor information or to register for the conference, visit our website at www.aws.org/conferences or call 800-443-9353, ext. 462.
COMING EVENTS

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


♦ AWS Detroit Sheet Metal Welding Conf. XIV May 11–14, Vis-Tech Center, Livonia (Detroit), Mich. Contact American Welding Society Detroit Section at smew@awsdetroit.org, or visit www.awsdetroit.org.


Int’l Symposium on Surface Hardening of Corrosion-Resistant Alloys. May 25, 26, Case Western Reserve University, Cleveland, Ohio. Visit www.asminternational.org.


Los Alamos National Laboratory - a premier national security research institution delivering innovative science and engineering solutions for the nation’s most crucial and complex problems – has the following opening:

**SCIENTIST III**

As part of the Welding and Joining Team of the Materials Science and Technology Metallurgy Group, the chosen candidate will conduct and oversee research related to weapons manufacturing, act as key liaison between the engineering and manufacturing functions, and manage/prioritize a variety of engineering projects and processes. This position assumes responsibility for coordinating engineering resources to meet project deadlines and requirements, directs technical feasibility reviews, and recommends processes and design improvements and plant layout changes for optimum manufacturing efficiency. Mentoring junior staff and multidisciplinary teams will also be expected.

Qualified candidates must demonstrate expertise with Electron Beam Welding (EBW) and Gas Metal Arc Welding, and an understanding of how welding processes impact microstructure evolution, creation of weld anomalies and development of residual stress. A Ph.D. in Welding Engineering, Metallurgical Engineering or Materials Science (or equivalent degree and experience) is required, along with experience in metal fabrication processing and strong analytical skills.

For specific questions about this position, call (505) 665-1683. Please submit your application online at www.lanl.gov/jobs, and apply to job number 218908.

Los Alamos National Laboratory

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◊ Trends in Welding Conf. Aug. 2–5, Cherry Valley Lodge, Newark, Ohio. Cosponsored by American Welding Society and Edison Welding Institute. Contact George Ritter (614) 688-5199; gritter@ewi.org.

◊ ICWJM 2010, Third Int'l Conf. on Welding and Joining of Materials, and Int'l Welding Show Peru. Aug. 9–11, Lima, Peru. To feature weldability of advanced alloys, modeling processes, distortion, advanced NDE of welds, welder training, special welding and joining processes, technology transfer, etc. Sponsored by the AWS Peru Section, organized by Soldexa S.A. and Pontifical Catholic University of Peru in collaboration with the University of Chicago. Visit www.pucp.edu.pe/icwjm/ingles/index.html.


Canadian Manufacturing Week 2010. Oct. 5–7, Toronto Congress Centre, Toronto, Ont., Canada. Sponsored by Society of Manufacturing Engineers. Call (888) 322-7333; canadasales@sme.org.


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Eduational Opportunities


Basics of Nonferrous Surface Preparation. Online course, six hours includes exam. Offered on the 15th of every month during 2010 by The Society for Protective Coatings. Members $145, nonmembers $245. Register online at www.sspsc.org/training.


Brazing Fundamentals Training Seminars. May 18–20, Ramada Inn Airport, Hartford, Conn.; Oct. 5–7, Embassy Suites, Greenville, S.C. Covers furnace, torch, induction, etc., as well as all filler metal types (Ni, Cu, Ag, Al, etc.). Contact Kay & Associates (860) 651-5595, or visit www.kaybrazing.com.


Preparation and Exam for AWS Certified Welding Inspector/Educator. Two-week-long courses beginning May 17, June 21, Aug. 9, Sept. 20, Nov. 1, Nov. 29 in Troy, Ohio. Call Hobart Institute of Welding Technology (800) 332-9448; hiwt@welding.org; or visit www.welding.org.

Preparation and Exam for AWS Certified Welding Supervisor. One-week-long course begins May 3, Oct. 18 in Troy, Ohio. Call Hobart Institute of Welding Technology (800) 332-9448; hiwt@welding.org; or visit www.welding.org.

ASMI Int'l Courses. Numerous classes on welding, corrosion, failure analysis, metallography, heat treating, etc., presented in Materials Park, Ohio, online, webinars, on-site, videos and DVDs. Visit www.asminernational.org, search for “courses.”


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

Consumables: Care and Optimization. Free online e-courses presenting the basics of plasma consumables, designed for plasma operators, distributor sales and service personnel, etc. Visit www.hyperthermcuttinginstitute.com.

CWI/CWE Course and Exam. Troy, Ohio. This is a two-week preparation and exam program. For schedule, call Hobart Institute of Welding Technology (800) 332-9448, or visit www.welding.org.

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. Call Welder Training & Testing Institute (800) 223-9884, info@wtti.edu; or visit www.wtti.edu.


Preparation and Exam for AWS Certified Welding Inspector/Educator. Two-week-long courses beginning May 17, June 21, Aug. 9, Sept. 20, Nov. 1, Nov. 29 in Troy, Ohio. Call Hobart Institute of Welding Technology (800) 332-9448; hiwt@welding.org; or visit www.welding.org.

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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. Call Welder Training & Testing Institute (800) 223-9884, info@wtti.edu; or visit www.wtti.edu.

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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.

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For information on any of our seminars and certification programs, visit our website at [www.aws.org/certification](http://www.aws.org/certification) or contact AWS at (800) 443-9533, 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.

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THE WORLD OF ENERGY – WELDING’S GREATEST CHALLENGE

August 31 - September 1, 2010
San Diego, CA

Much of our welding future depends on the ability of the industry to adapt and promote its technologies to new energy industries.

Examine the many avenues of energy including the important aspects of coal-powered plants, the present and future of nuclear power, activities in pipeline construction, land-based and offshore work in liquefied natural gas, solar energy, wind power and much more…
Conference Program

- The National Science Foundation’s New Center for Integrative Materials Joining
  Sudarsanam (Suresh) Babu – NSF Center for Integrative Materials Joining Science for Energy Applications - Columbus, OH

- Westinghouse’s Position in the Nuclear Renaissance
  Lance S. Harbison, - Westinghouse Electric Company, Energy Center - Pittsburgh, PA

- Advances in Submerged Arc Welding of Wind Towers
  Teresa Melfi - Lincoln Electric Co. - Cleveland, OH

- Capabilities in Offshore Welding at Kiewit Offshore Services
  Richard Marslender - Kiewit Offshore Services, Ltd. - Ingleside, TX

- The Use of a Tempering Parameter for the Control of PWHT of Grade P91 and Other CESF Steels
  Jeff Henry - Structural Integrity Associates - Chattanooga, TN

- Using the Latest Technology for Heating and Welding Chrome-Moly Pipe
  James A. Byrne - Miller Electric Manufacturing Co. - Appleton, WI

- Welding Challenges of Liquefied Natural Gas Facilities
  Ben Pletcher - Chicago Bridge & Iron Co. - Plainfield, IL

- Narrow Groove Tandem GMAW and HLAW for Wind Tower and Nuclear Fabrication
  Ian Harris - Edison Welding Institute - Columbus, OH

- EV Batteries & Weld Process Variation
  Benjamin Christian and Daniel Hutchinson - General Motors LLC. - Warren, MI

- Advancements in Pipeline Field Construction Welding
  Kevin A. Beardsley - Lincoln Electric Company - Cleveland, OH

- Explosion Welding and Its Application in Downstream Oil Refineries
  Michael Blakely - Dynamic Materials Corporation - Sugar Land, TX

- Duplex Stainless Steels and Nickel-Based Alloys: An Overview
  Cheryl Botti - ATI Allegheny Ludlum - Brackenridge, PA

- Laser-Based Additive Processes for Energy – Related Applications
  Todd Palmer - Pennsylvania State University - State College, PA

- Energy Applications for Advanced Joining Processes
  Ed Hansen - ESAB Welding & Cutting Products - Florence, SC

- The Nuclear Scene
  Nate Ames - Edison Welding Institute - Columbus, OH

- Dissimilar Metal Welding
  Donald J. Tillack - Tillack Metallurgical Consultants Inc. - Catletsburg, KY

For more information on attending or exhibiting at the conference, please visit www.aws.org/conferences or call 800-443-9353 ext. 462
Master Chart Classifies the Latest Welding Process Developments

The American Welding Society formed the A2 Committee on Definitions and Symbols to establish standard terms and definitions to aid in the communication of welding information. A3.0, Standard Welding Terms and Definitions, is the major product of work done by the Subcommittee on Definitions in support of that purpose.

The latest edition of A3.0, which has just recently become available, defines more than 1400 terms, with 60 illustrations to support and clarify the definitions, as well as classification charts and corollary information related to welding and allied processes. This latest revision includes significant enhancements to terms relating to brazing, resistance welding, and soldering. It addresses hybrid processes for the first time and includes new process groupings such as high energy beam welding (HEBW) and thermal gouging (TG). The Master Chart of Processes (Fig. 1) has been revised to classify the latest process developments and enhancements. A3.0 is available through World Engineering Xchange (WEX), Ltd., at www.awspubs.com.

Fig. 1 — Master chart of welding and joining processes.

BY NATALIE TAPLEY

The Welding Equipment Manufacturers Committee (WEMCO) and the Resistance Welding Manufacturing Alliance (RWMA) held their first co-located annual meeting March 11–13 at the PGA National Resort and Spa, in Palm Beach Gardens, Fla., for 145 attendees. Attending were Roger Hirsch, RWMA chair, and Jeff Deckrow, WEMCO chairman.

The meeting featured discussions on the most important issues affecting the membership organizations. Uppermost are concerns about how to proceed in the postrecession business environment that has impacted many of the members — professionally and personally. The program featured four dynamic and influential speakers from the welding, manufacturing, and automobile industries who shared their knowledge on this and other important topics.

Emily DeRocco, president of Manufacturing Institute, the National Association of Manufacturers’ (NAM) research, education and workforce affiliate in Washington, D.C., spotlighted the challenges manufacturers are facing today amidst the economic recovery, as well as the importance of closing the skills gap if our nation is to compete successfully in the global marketplace, and remain a world leader in innovation. She explained how a new NAM-endorsed Manufacturing Skills Certification System “will revolutionize education and training for the 21st century manufacturing workforce. The system will initially focus on the core, basic skills required for entry-level workers in all sectors of manufacturing, from alternative energy and computers to aerospace and life-saving pharmaceuticals. The core skills will include personal effectiveness, academic competencies, workplace competencies, and industry-wide technical competencies such as supply chain logistics and health and safety.

David Cole, chairman, Center for Automotive Research (CAR), reviewed today’s turbulent automotive industry, as well as the importance of creating a foundation for future success. He pointed out that all stakeholders — from manufacturers and suppliers to dealers and consumers — are in the midst of a most challenging period. However, the good news is, he said, that because of the current turmoil, policymakers are beginning to understand the needs of the manufacturing and auto industries.

Martin Quinn, president, Thermadyne Holdings Corp., presented an overview of the past year at his company, along with economic indicators that helped the company evaluate the business climate. He also discussed how these economic indicators have helped the company to manage and adapt to the changing environment by implementing a new culture to emerge a better and stronger enterprise.

Jeff Dietrich, economist at the Institute for Trend Research, presented the much-anticipated economic forecast report. The meeting attendees found his presentation insightful and entertaining.

WEMCO held its first Member-to-Member Business Exchange Roundtable discussions. The event gave the members the opportunity to participate in discussions with their industry peers on topics they deem most important. It offered members a venue that was conducive to productive business discussions, and allowed them to gain many different perspectives from their peers.

The RWMA also held its committee and subcommittee meetings where many pertinent and outstanding issues were addressed.

In all, the 2010 colocated annual meeting proved to be a complete success; however, there are no immediate plans to continue or discontinue the colocated annual event.

The RWMA and WEMCO are standing committees of the American Welding Society. The committees represent companies interested in the advancement of the resistance welding process in industry, and the manufacturers making products for welding processes and applications, respectively.

NATALIE TAPLEY (tapley@aws.org) is program manager, Welding Equipment Manufacturers Committee.
Three updated standards have been issued, superseding their previous editions: A3.0M/A3.0:2010, Standard Welding Terms and Definitions; A5.11/A5.11M:2010, Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding; and A5.22/A5.22M:2010, Specification for Stainless Steel Flux Cored and Metal Cored Welding Electrodes and Rods.

The A3.0 document standardizes terminology for welding, brazing, soldering, thermal spraying, adhesive bonding, and, for the first time, hybrid processes. Included in its 160 pages are more than 1400 terms and 60 illustrations. The list price is $148, $111 for AWS members.

The A5.11 specification supersedes the 2005 revision. The 50-page document lists for $52, $39 for AWS members.

The A5.22 specification details the electrodes used for gas metal arc, gas tungsten, plasma arc, and submerged arc welding processes. The 66-page document lists for $52, $39 for AWS members.

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Technical Committee Volunteer Opportunities

Armament Systems Welding
The recently formed D14H Subcommittee on Armament Systems Welding seeks volunteers to help prepare welding standards for armament systems. Represented are members of the military, defense contractors, research institutes, heavy manufacturing, robotics, consulting and inspection firms, and others. It is the intent that D14J’s standards will supersede U.S. TACOM’s ground combat vehicle Welding Codes 12479550 and 12472301 for steel and aluminum. Contact Matt Rubin, mrubin@aws.org; (800/305) 443-9353, ext. 215, to contribute to this important work.

Surfacing Industrial Mill Rolls
Volunteers are sought to contribute their expertise to the D14H Subcommittee on Surfacing and Reconditioning of Industrial Mill Rolls to revise AWS D14.7, Recommended Practices for Surfacing and Reconditioning of Industrial Mill Rolls. Persons involved in this field are asked to contact Matt Rubin, mrubin@aws.org; (800/305) 443-9353, ext. 215, or visit www.aws.org/1UQ4 to apply online.

Welding Sales Representatives
AWS established a new certification program for welding sales representatives in 2009. Volunteers are invited to be part of the technical subcommittee responsible for setting the qualification requirements, AWS B5.14, Specification for the Qualification of Welding Sales Representatives, that this program is based on. Contact John Gayler, gayler@aws.org; (800/305) 443-9353, ext. 472; or visit www.aws.org/1UQ4.

Robotic and Automatic Welding
Volunteers are sought to contribute their expertise to the D16 Committee on Robotic and Automatic Welding. Its documents include D16.1, Specification for Robotic Arc Welding Safety; D16.2, Guide for Components of Robotic and Automatic Arc Welding Installations; D16.3, Risk Assessment Guide for Robotic Arc Welding; D16.4, Specification for Qualification of Robotic Arc Welding Personnel. Persons engaged in robotic welding operations and suppliers of equipment who want to contribute their expertise to the preparation of one or more of these documents are urged to contact Matt Rubin, mrubin@aws.org; (800/305) 443-9353, ext. 215, or apply online at www.aws.org/1UQ4.

Magnesium Alloy Filler Metals
Volunteers are invited to participate on the A5L Subcommittee on Magnesium Alloy Filler Metals. This subcommittee is responsible for updating AWS A5.19-92 (R2006), Specification for Magnesium Alloy Welding Electrodes and Rods. For complete information, contact Subcommittee Secretary Rakesh Gupta at Gupta@aws.org, or call (800/305) 443-9353, ext. 301; or visit www.aws.org/1UQ4 to submit your member application online.

Thermal Spraying
Volunteers are invited to participate on the C2 Committee on Thermal Spraying. Several of its documents include C2.16, Guide for Thermal-Spray Operator Qualification; C2.18, Guide for the Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and their Alloys and Composites; C2.19, Machine Element Repair; C2.23, Specification for the Application of Thermal Spray Coatings (Metallizing) of Aluminum, Zinc, and Their Alloys and Composites for Corrosion Protection of Steel. Contact Reino Starks, rsiarks@aws.org; (800/305) 443-9353, ext. 304, for information, or visit www.aws.org/1UQ4 to apply online.

Labeling and Safe Practices
Volunteers are needed to participate on the SH4 Subcommittee on Labeling and Safe Practices. Its documents include F2.2, Lens Shade Selector; F4.1, Safe Practices for the Preparation of Containers and Piping for Welding and Cutting, and the AWS Safety and Health Fact Sheets. For additional information about this committee’s work, contact Steve Hedrick, steveh@aws.org; (800/305) 443-9353, ext. 305; or submit a technical committee application online at www.aws.org/1UQ4.

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 FABTECH 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 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.
Member-Get-A-Member Campaign

Listed below are the AWS members who are participating in the 2009–2010 campaign. See page 85 in this Welding Journal or visit www.aws.org/mgm for the campaign rules and prize list.

The following standings are as of March 17, 2010. Call the AWS Membership Dept. (800/305) 443-9353, ext. 480, for information on your member-proposer status.

### Member-Get-A-Member Campaign

#### 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 Valley
J. Ciaramitaro, N. Central Florida — 5
J. Hennessy, Fox Valley — 6
J. Compton, San Fernando Valley — 13
J. Merzthal, Peru
J. Rudden, Colorado
T. Rowe, Tulsa
F. Nguni, New Jersey
D. Mandina, New Orleans
K. Hurst, Kansas City
M. Haynes, Niagara Frontier
R. Davis, Utah
K. Carter, Tri-River
T. Blakeney, Green & White Mountains
P. Newhouse, British Columbia — 3
T. Morris, Tulsa — 3
E. Ezell, Mobile — 4
E. Ravelo, International — 4
D. Duron, New Orleans — 20
A. Baughman, Stark Central — 23
H. Browne, New Jersey — 10
H. Thompson, New Orleans — 12
W. Galvery, Long Bch./Or. Cty. — 11
J. Stallsmith, South Carolina — 11
H. Browne, New Jersey — 10

#### 3+ Student Member Sponsors

D. Saunders, Lakeshore — 35
C. Rogers, San Antonio — 49
G. Kirk, Pittsburgh — 47
H. Hughes, Mahoning Valley — 41
D. Berger, New Orleans — 38
S. Miner, San Francisco — 36
J. Morash, Boston — 36
C. Hardberger, Mid-Ohio Valley — 35
G. Grammill, New Orleans — 34
D. Kelter, Willamette Valley — 34
C. Lindquist, Central Michigan — 32
R. Durham, Cincinnati — 31
J. Carney, Western Michigan — 29
M. Anderson, Indiana — 28
D. Kowalski, Pittsburgh — 27
D. Zabel, NE Nebraska — 25
M. Boggs, Stark Central — 24
S. Siskivi, Maine — 24
A. Baughman, Stark Central — 23
R. Hutchison, Long Bch./Or. Cty. — 23
R. Gerber, Allegheny — 22
R. Wahrman, LA./Inland Empire — 22
D. Aragon, Puget Sound — 21
T. Geisler, Pittsburgh — 21
S. Burdge, Stark Central — 20
A. Duron, New Orleans — 20
R. Evans, Siouxland — 20
E. Norman, Ozark — 20
G. Marx, Tri-River — 20
K. Rawlins, Columbus — 20
B. Suckow, Northern Plains — 20
C. Donnell, NW Ohio — 19
J. Durbin, Tri-River — 19
V. Facchiano, Lehigh Valley — 19
J. Theberge, Boston — 19
M. Arand, Louisville — 18
J. Boyer, Lancaster — 18
R. Boyer, Nevada — 18
W. Davis, Syracuse — 18
J. Fox, NW Ohio — 18
J. Roberts, Sacramento — 18
K. Carter, Tri-River — 17
R. Schmidt, Philadelphia — 17
G. Smith, Lehigh Valley — 17
D. Vanich, N. Florida — 17
N. Baughman, Stark Central — 16
J. Daugherty, Louisville — 16
A. Reis, Pittsburgh — 16
G. Scece, Johnstown-Altoona — 16
W. Garrett, Olympic — 15
A. Stute, Madison-Beloit — 15
M. Vann, S. Carolina — 15
R. Vann, S. Carolina — 15
B. Benyon, Johnstown-Altoona — 14
J. Ciaramitaro, N. Central Florida — 14
J. Gerdin, Northeast — 14
J. Kline, Northern New York — 14
R. Muns, Utah — 14
W. Seyfarth, Central Florida — 14
S. Mattson, N. Florida — 12
H. Thompson, New Orleans — 12
G. Rodeman, Sierra Nevada — 12
W. Galvery, Long Bch./Or. Cty. — 11
J. Stallsmith, South Carolina — 11
H. Browne, New Jersey — 10

#### 1+ Student Member Sponsors

D. Garcia, New Orleans — 10
W. Harris, Pascaugola — 10
S. Kunz, Pittsburgh — 10
R. Rummel, Central Texas — 10
C. Schiner, Wyoming — 10
P. Swatland, Niagara Frontier — 10
V. Hartman, Northern Plains — 8
J. Hill, Puget Sound — 8
J. Fitzpatrick, Arizona — 7
A. Mattox, Lexington — 7
D. Roskiewich, Philadelphia — 7
J. Grossman, Central Michigan — 6
M. Hayes, Puget Sound — 6
R. Jones, Puget Sound — 6
T. Palmer, Columbia — 6
A. Badeaux, Washington, D.C. — 5
S. Colton, Arizona — 5
D. Howard, Johnstown-Altoona — 5
D. Kears, Northern Michigan — 5
S. Liu, Colorado — 5
T. Strickland, Arizona — 5
R. Davis, Syracuse — 4
S. Hansen, NE Nebraska — 4
S. Henson, Spokane — 4
R. Hilty, Pittsburgh — 4
E. Hinojosa, LA./Inland Empire — 4
G. Kimbrell, St. Louis — 4
A. Kitchens, Olympic Section — 4
J. Lynn, Idaho-Montana — 4
S. Mackenzie, Northern Michigan — 4
R. Madrigal, LA./Inland Empire — 4
D. Newman, Ozark — 4
M. Pelegrino, Chicago — 4
J. Pummer, Long Bch./Or. Cty. — 4
R. Richwine, Indiana — 4
J. Smith, Greater Huntsville — 4
M. Stevenson, J.A.K. — 4
J. Boyd, San Diego — 3
N. Carlson, Idaho-Montana — 3
B. Chin, Auburn — 3
J. Compton, San Fernando Valley — 3
T. Crate, Drake Well — 3
D. Crow, Houston — 3
C. Gilbertson, Northern Plains — 3
S. McDaniell, Inland Empire — 3
G. Moore, San Diego — 3
S. Robeson, Cumberland Valley — 3
A. Rodden, Tennessee — 3

### AWS Membership Counts

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<tr>
<td>Student + transitional</td>
<td>8,652</td>
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<td>Total members</td>
<td>61,971</td>
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**Member**

- As of 04/01/10

**Supporting**

- 309

**Sustaining**

- 514

**Affiliate**

- 478

**Educational**

- 519

**Welding distributor**

- 47

**Total corporate members**

- 1,867

**Individual members**

- 53,319

**Student + transitional members**

- 8,652

**Total members**

- 61,971
District 1

Thomas Ferri, director
(508) 527-1884
tferri@thermadyne.com

BOSTON

MARCH 6
Activity: The Section, in conjunction with Assabet Valley Regional Technical High School, held a two-day workshop featuring metal fabrication specialist Fay Butler. Butler demonstrated straightening and shaping a flat piece of steel into elaborate curved sections using only a hammer and heat. He uses his talents to shape metals for restoration of antique automobiles. The event was held at the school in Marlboro, Mass.

MARCH 15
Activity: The Section members toured the manufacturing division of Rolls Royce Naval Marine facilities in South Walpole, Mass. The sights included fabrication and balancing of propellers for large naval, cruise, and cargo vessels. Conducting the tour were Walter Roy, Dick Olobri, and welding specialist Paul Campenella.

CONNECTICUT

FEBRUARY 16
Activity: The Section members joined members of the local chapter of ASM International for a tour of the Precision Technologies (PTR) facilities in Enfield, Conn. John Rugh, ASM technical chair, opened the program with an introduction to electron beam welding (EBW) and what would be on display during the tour. Following the dinner, hosted by PTR, Guenther Schubert presented a lecture on the advantages and limitations of EBW with comparisons to laser beam welding technology. The 30 attendees braved a snowstorm to attend the event.

GREEN & WHITE MOUNTAINS

MARCH 13
Activity: The Section members conducted a welding contest for 15 secondary-level welding students to prepare for the SkillsUSA welding competition. Participating were Chair Geoff Putnam, lead instructor Ed Loprette, Ernie Plumb, Jim Reid, Phil Witteman, Gary Buckley, Ray Henderson, John Steel, Russ Norris, and Jerry Ouellette. The event was held at Advanced Welding Institute in Williston, Vt. Earlier, the New England Chapter of the Poor Pooped Past District 1 Directors, headed by Geoff Putnam, met for a breakfast meeting at the Arcade Diner in South Burlington, Vt. The agenda included a tour of an authentic 1950s stainless steel Worcester dining car.
Green & White Mountain Section pros oversaw the welding contest. Shown are (from left) Ernie Plumb, Jim Reid, Chair Geoff Putnam, Phil Witterman, Ed Loprette, Gary Buckley, Ray Henderson, John Steel, and Jerry Ouellette.

Shown at the Pennsylvania College of Technology Student Chapter tour are (from left) Lee Asbeck, Nate Myers, Logan Kucerak, Tyler Caldwell, Bill Badger, Derek Hurley, Zach MacMullen, Greg Rhodes, Eric Speer, Tim Turnback, and Lindsey Anderson.

District 2
Kenneth R. Stockton, director
(908) 412-7099
kenneth.stockton@pseg.com

LONG ISLAND
MARCH 11
Activity: The Section members met at The Nook Restaurant in Wantagh, N.Y., for a discussion on the Brookhaven Labs’ welding projects. Participating were Chair Brian Cassidy, Harland Thompson, Tom Gartland, Ray O’Leary, and Barry McQuillen.

NEW YORK
FEBRUARY 8
Activity: The Section members met for a business meeting and a round table discussion on welding problems and solutions. The meeting was held at Buckley’s Restaurant in Brooklyn, N.Y.
Triangle Section members and guests are shown during their tour of Altec Industries.

**District 3**
Michael Wiswesser, director  
(610) 820-9551  
mike@welderinstitute.com

**Pennsylvania College of Technology Student Chapter**  
**MARCH 2**
Activity: The Chapter members toured the manufacturing facility of the Aker Philadelphia Shipyard in Philadelphia, Pa., to study all aspects of the shipbuilding operation. Keith Viney, QC and welding manager, and James Clark conducted the tour.

**READING**  
**FEBRUARY 18**
Speaker: Charles Motchenbacher, technology manager, powder products  
Affiliation: Reading Alloys, Inc.  
Topic: Titanium, its mining, extraction, alloying, powder production, and applications  
Activity: Past chairmen in attendance included Joe Young, Steve Gammon, Peter Shaub, Paul Levengood, Merilyn McLaughlin, and David Hibshman. District 3 Director Mike Wiswesser reported the new AWS projects.

**YORK-CENTRAL PA.**  
**FEBRUARY 4**
Activity: The Section members met at York County School of Technology in York, Pa., for a demonstration of orbital welding of stainless steel tubing. The presenter was Wes Mekrut of Mekrut Sales Co.

**District 4**
Roy C. Lanier, director  
(252) 321-4285  
rlanier@email.pittcc.edu

**TRIANGLE**  
**FEBRUARY 18**
Activity: The Section members met at Altec Industries, Inc., near Raleigh, N.C., for a tour of the facility. The company manufactures derricks, overhead cranes, industrial trucks and tractors. Stewart

**District 5**
Steve Mattson, director  
(904) 260-6040  
steve.mattson@yahoo.com

**FLORIDA WEST COAST**  
**MARCH 10**
Speaker: Dale Ison, mfg./QA manager  
Affiliation: Tampa Tank, Inc., Florida Structural Steel  
Dale Ison (right) receives a speaker-appreciation gift from Robert Brewington, Florida West Coast Section chairman.
Shown at the North Florida Section welding competition are (from left) District 5 Director Steve Mattson, Jim Issa, and Sam Gentry.

Drew Duffy (left) and Craig Bachler (center) are shown with Steve Mattson, District 5 director, at the North Florida Section March 18 program.

Speaker Mark Yaple (right) accepts a speaker gift from Dave Parker, Northern New York Section secretary.

Paul Bevilaqua discussed aerospace engineering topics for the Columbus Section and other local technical societies in February.

### NORTH FLORIDA

**March 3**  
Activity: The Section members participated in the welding competition held at Tulsa Welding School in Jacksonville, Fla. First prize was a full scholarship from Tulsa Welding. Participating in the event were District 5 Director Steve Mattson, Jim Issa from Lincoln Electric, and Sam Gentry, executive director, AWS Foundation. High school seniors nationwide participated in the contest. Issa showed the students how to use the VR 360, a virtual reality welding simulator training machine.

**March 18**  
Activity: Craig Bachler and Chris Hobson demonstrated the Fronius CMT 2700, a water-cooled, cold metal transfer, pulsed gas metal arc welding system. Then, they assisted the attendees with a hands-on trial of the equipment. This North Florida Section program was held at Tulsa Welding School in Jacksonville, Fla. Participating were Drew Duffy of Tulsa Welding School and Steve Mattson, District 5 director.

### District 6

Kenneth Phy, director  
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KAPhylnc@gmail.com

**Niagara Frontier**  
**February 27**  
Activity: The Section hosted its 14th annual weld off contest in Buffalo, N.Y. The participating welding instructors included Eric Farell, Kevin Valentine, and Steven Fry. The top contenders included Elliott Vanderwaltor, Eric Gorecki, Travis McCarthy, Dylan Korte, Chair Fred Schmidt, Nick Radosky, Steven Fry, and Alan Willis.
NORTHERN NEW YORK
FEBRUARY 9
Speaker: Mark Yaple, technical sales engineer
Affiliation: Avesta Welding, LLC
Topic: Welding duplex stainless steel
Activity: This was a joint meeting with members of the Eastern New York Chapter of ASM International. Dave Parker, Section secretary, made the desk clock that he presented to Yaple in appreciation for his presentation. The program was held at Mill Road Restaurant & Tavern near Schenectady, N.Y.

District 7
Don Howard, director
(814) 269-2895
howard@ctc.com

COLUMBUS
FEBRUARY 18
Speaker: Paul Bevillaqua, chief engineer of advanced development projects
Affiliation: Lockheed Martin Skunk Works®
Topic: Inventing the Joint Strike Fighter
Activity: The Columbus Section members meet regularly with members of the local chapters of SWE, ASME, ASM International, IIE, AIAA, ISA, and NACE. The organizations take turns hosting the monthly programs. This program was held at Arlington Banquets in Columbus, Ohio.

DAYTON
MARCH 9
Speakers: Chris Lander, Mike Yauger, and Bill Jones
Affiliation: St. John Inspection Services, Ironworkers Local 290 (ret.)
Topic: How to succeed in welding by working really hard
Activity: The program was held at Hobart Brothers Co., in Troy, Ohio.

District 8
Joe Livesay, director
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joe.livesay@ttcc.edu

NASHVILLE
MARCH 4
Speaker: John Mark McMurtry, coowner
Affiliation: Volunteer Welding Supply
Topic: The company’s products and services
Activity: Following the talk, 28 Section members toured the company’s showroom and facility for filling gas cylinders. David McMurtry assisted with the tour. The company hosted the event, including a fried chicken dinner and numerous valuable door prizes.

District 9
George D. Fairbanks Jr., director
(225) 473-6362
fits@bellsouth.net

ACADIANA-MORGAN CITY
MARCH 16
Speaker: George Fairbanks, District 9 director
Affiliation: Fairbanks Inspection & Testing
Topic: The AWS CWI and renewal requirements referencing QC1-2007 and B5.1
Activity: This was a joint meeting of the two Sections, hosted by the Acadiana members headed by Chairman Mike Skiles. The program was held at Landry’s Seafood House.
BIRMINGHAM
February 24, 25
Activity: The Section and AWS Greater Huntsville Section cosponsored the 15th annual workshop for students in various crafts. The workshop offered an opportunity for 66 welding instructors from across Alabama to train and fellowship together. The presenters included Lincoln Electric, ESAB, Miller Electric, United Association, Airgas South, and Tuscaloosa Plumbers and Pipefitters Local 372, who hosted the event. The program began with classroom activities, followed by hands-on application exercises in the shop areas. Bob Kimbrell coordinated the event.

MOBILE
February 11
Speaker: Ryan O’Dell, district manager
Topic: Effects of induction heating on welding plate and pipe
Activity: James Smith of Austal USA received the Private Sector Instructor of the Year Award from Ron Pierce, AWS president 1997–1998. Daniel Madden received a scholarship check from Jim Sullivan. The meeting was held at Saucy Q Bar B Que in Mobile, Ala.

NEW ORLEANS
January 19
Meeting sponsor Rodney Dufour (center) is shown with New Orleans Section Chair Donald Berger (right) and George Fairbanks, District 9 director, in January.

Speaker: John Bruskotter, AWS president
Affiliation: Bruskotter Consulting Services
Topic: Welding on offshore platforms
Activity: This New Orleans Section meeting, held at Boomtown Casino in Harvey, La., was sponsored by Inspection Specialists and organized by Rodney Dufour. District 9 Director George Fairbanks and Section Chair Donald Berger presided. Ninety-five people attended the event.

February 23
Speaker: Chris Pietaroi
Affiliation: Airgas
Topic: Procedures for filling gas cylinders
Activity: Airgas sponsored this meeting, held at its new facility in Harvey, La. Mike Davis and Chris Pietaroi of Airgas organized the meeting for 102 attendees.

District 10
Richard A. Harris, director
(440) 338-5921
richaharris@windstream.net

DRAKE WELL
March 9
Activity: The Section members met at Venango Technology Center in Oil City, Pa., to tour the Section’s technical library maintained by Carol Miller. Section Secretary Travis Crate, a welding instructor at the center, demonstrated gas tungsten arc welding then offered attendees the opportunity to test their welding skills.

MAHONING VALLEY
February 10
Speaker: Robert Matteson
Affiliation: Taylor-Winfield Corp.
Topic: Resistance welding basics and equipment
Activity: The program, held at Café 422 in Warren, Ohio, was a joint meeting with members of the local chapter of ASM International.

February 19
Activity: The Mahoning Valley executive committee met to discuss plans for hosting the District 10 conference scheduled to be held May 7 at the Steel and Iron Museum in Youngstown, Ohio. The meeting was held at Steamer’s Restaurant in North Lima, Ohio.

Speaker Ryan O’Dell (right) is shown with Randy Henderson at the Mobile Section February event.

Speaker John Bruskotter, AWS president, spoke at the New Orleans Section event in January.

James Smith (left) receives the Private Sector Instructor Award from Ron Pierce, an AWS past president, at the Mobile Section meeting in February.

District 11
Eftihios Siradakis, director
(989) 894-4101
ft.siradakis@airgas.com

DETROIT
March 11
Speaker: Pierre Barthelemy, CEO
Affiliation: ARO Welding Technologies
The Detroit Section recognized (from left) Tim Cesarz, Steve Esders, Rod Bereznicki, and Mike D’Agostin, for their services to the Section.

Speaker Chad Krueger (left) is shown with Chuck Frederick, Lakeshore Section chair.

Robert Smith discussed welding steel at the Lexington Section program.

Shown at the Lexington Section program are (from left) welding instructor Bobby Coffee, scholarship recipient Ryan Tomi, and Chairman James Mattox.

Shown at the Detroit Section program are (from left) speaker Pierre Barthelemy, Bernie Marini, and Chairman John Bohr.

Welding contestants shown at the Indiana Section welding contest are (from left) Jerod Higdon, Brandon Jackson, Matt Brennan, Caleb Coffin, and Greg Carper.

Topic: The use of servo technology and force sensors in projection welding
Activity: The Detroit Section presented recognition awards to five of its corporate sponsors. Accepting the awards were Pierre Barthelemy and Bernie Marini, representing the host company, ARO Welding Technologies; Tim Cesarz, representing CenterLine Ltd.; Rod Bereznicki, accepting for KUKA Systems Corp.; and Mike D’Agostin, representing RoMan Engineering Services, Inc. Also recognized for individual contributions to the Section’s activities were Wanda Newman, Don Czerniewski, Steve Esders, and Larry Vanderstelt. The program was hosted by ARO Welding Technologies in Chesterfield, Mich.
The 5th Annual District 12 Winter Meeting Is Another Big Success

Awardees at the District 12 winter meeting included (from left) Dan Crifase (Racine-Kenosha), Larry Bower (Madison-Beloit), Bob Ellenbecker (Fox Valley), Dale Holschbach (Lakeshore), Craig Wentzel (Milwaukee), Ken Karwowski (Racine-Kenosha), Karen Gilgenbach (Milwaukee), and Sean Moran, District 12 director.

District 12
Sean P. Moran, director
(920) 954-3828
sean.moran@hobartbrothers.com

District 12 Winter Meeting
FEBRUARY 12
Activity: The District held its fifth annual winter meeting at Roma Lodge, Racine, Wis. A full day of camaraderie, dining, educational talks, awards presentations and an industrial tour. Debra Lovedahl of CNH America, a manufacturer of farm tractors, arranged for the group to enjoy a two-hour-long tour of the facility. The event, hosted by the Racine-Kenosha Section was organized by Chair Dan Crifase, Vice Chair Ken Karwowski, and Sean Moran, District 12 director. Participating were the Fox Valley, Lakeshore, Madison-Beloit, Milwaukee, Racine-Kenosha, and Upper Peninsula Sections. Recognized for awards were Dan Crifase and Ken Karwowski (Racine-Kenosha), Larry Bower (Madison-Beloit), Bob Ellenbecker (Fox Valley), Dale Holschbach (Lakeshore), Craig Wentzel and Karen Gilgenbach (Milwaukee). Recognized for awards in their absence were Jim Renner, Private Sector Educator Award; and John Hinrichs and Rob Stinson, Meritorious Awards.

The previous District winter meetings have been a great success, with attendances reaching 200. The plant tours have included Manitowoc Crane Co., Miller Electric Mfg. Co., Bucyrus Erie, and John Deere. The event was the brainchild of Sean Moran, District 12 director, who conceived it as an opportunity for each Section to have the opportunity to serve as the host Section for a meeting each year. The Racine-Kenosha Section hosted this year.

District 13
W. Richard Polanin, director
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rpolanin@icc.edu

District 14
Tully C. Parker, director
(618) 667-7795
tullypharker@charter.net

INDIANA
FEBRUARY 20
Activity: The Section’s members conducted and judged the Indianapolis regional welding contest for SkillsUSA. Twenty-five students competed for the four spots in the Secondary SkillsUSA state welding contest and one spot in the State Postsecondary Contest. The qualifiers from the New Castle Area Career Programs included Brandon Jackson, Caleb Coffin, and Matt Brennan. Other qualifiers were Jerod Higdon from Blue River Area Career Programs, and Greg Carper from Ivy Tech Community College. The event was held at Central Nine Career Center in Greenwood, Ind.

LEXINGTON
MARCH 4
Speaker: Robert Smith, district director
Affiliation: Lincoln Electric Co.
Topic: Welding steel
St. Louis Section members are shown during their tour of Jerry Haas Race Cars.

Arrowhead Section members are (from left) Dave Gerbensky, Dave Kantola, Neil Radaich, Lee Radaich, Bob Krog, Loren Kantola, Doug Mroz, and Jerry Russell.

Northwest Section welding contest winners included (from left) Kory Parchem, Steve Swenson, Alex Wickstrom, Carl Holland, Jeremy Hall, Max Bowers; Joe Tonsfeldt, Jeremy Hall, and Richard Thorp.

Activity: Ryan Tomi received the $500 Woodrow Scott Memorial Scholarship award from welding instructor Bobby Coffee and Chairman James Mattox. The meeting was held at Bluegrass Community College in Lexington, Ky., for 65 attendees.

ST. LOUIS
February 11
Activity: The Section members toured the Jerry Haas Race Cars, Inc., facility in Fenton, Mo. John DeFlorian, shop foreman, detailed the complete process the company uses to construct professional stock cars.

St. Louis Section members, vendors, and guests pose at the mini welding show in March.
Win Great Prizes in the 2009-2010 AWS Member-Get-A-Member Campaign*

ABOUT: AWS is looking for individuals to become part of an exclusive group of AWS Members who get involved and win. Give back to your profession, strengthen AWS and win great limited-edition prizes by participating in the 2009-2010 Member-Get-A-Member Campaign. By recruiting new members to AWS, you’re adding to the resources necessary to expand your benefits as an AWS Member. Year round, you’ll have the opportunity to recruit new members and be eligible to win special contests and prizes. Referrals are our most successful member recruitment tool. Our Members know first-hand how useful AWS Membership is, and with your help, AWS will continue to be the leading organization in the materials joining industry.

To recruit new Members, use the application on the reverse, or visit www.aws.org/mgm

PRIZE CATEGORIES
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.

International Sponsor Prize: Any member residing outside the United States, Canada and Mexico who sponsors the most new Individual Members will receive a complimentary AWS Membership renewal.

LUCK OF THE DRAW
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
* AWS hat

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.
AWS MEMBERSHIP APPLICATION

4 Easy Ways to Join or Renew:
- Mail this form, along with your payment, to AWS
- Call the Membership Department at (800) 443-9353, ext. 480
- Fax this completed form to (305) 443-5647
- Join or renew on our website <www.aws.org/membership>

☐ Mr. ☐ Ms. ☐ Mrs. ☐ Dr. Please print • Duplicate this page as needed

Last Name
First Name
Middle Initial
Title
Birthdate

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

Primary Phone ( ) Secondary Phone ( )
Fax ( ) Email

Did you learn of the Society through an AWS Member? ☐ YES ☐ NO
If "YES," Member's name: ______________________ Member's # (if known):
From time to time, AWS sends out informational emails about programs we offer, new Member benefits, savings opportunities and changes to our website. If you would prefer not to receive these emails, please check here ☐

ADDRESS

Company (if applicable)
Address
Address Con't.

City State/Province Zip/Postal Code Country

PROFILE DATA

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

PAYMENT INFORMATION (Required)

One-Year AWS Individual Membership $80
Two-Year AWS Individual Membership $160 $135 (New Members Only)

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

International Members add $10 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%...$20 (Optional)

International Members add $75 for book selection (note: $50 is for international shipping)...$45 (Optional)

(Note: Book Selection applies to new Individual Members only - Book selections on upper-right corner)

TOTAL PAYMENT $________

AWS STUDENT MEMBERSHIP $50

Domestic (Canada & Mexico incl.) $15
International $50
TOTAL PAYMENT $________

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:
☐ Check ☐ Money Order ☐ Bill Me
☐ American Express ☐ Diners Club ☐ Carte Blanche ☐ MasterCard ☐ Visa ☐ Discover ☐ Other

Your Account Number
Expiration Date (mm/yy)

Signature of Applicant:

Office Use Only: Check # ________ Account # ________ Application Date: __________

Source Code WJ

Two-year Individual Membership Special Offer: applies only to new AWS Individual Members. Additional Publication Offer: applies only to new AWS Individual Members. Select one of the 6 listed publications for an additional $75. International Members add $25. $25 for book selection and $30 for International Shipping. Multi-Year Discount: first year is $80, each additional year is $75. No limit on years (not available to Student Members).

New Member Renewal

BOOK/CD-ROM SELECTION
(Pay Only $25... up to a $192 value)

NOTE: Only New Individual Members are eligible for this selection. Be sure to add $25 to your total payment.

Only ONE SELECTION please:
☐ Jefferson’s Welding Encyclopedia (CD-ROM only)
☐ Design and Planning Manual for Cost-Effective Welding
☐ Welding Metallurgy
☐ Welding Handbook (9th Ed., Vol. 3)
☐ Welding Handbook (9th Ed., Vol. 2)
☐ Welding Handbook (9th Ed., Vol. 1)

For more book choices visit www.aws.org/membership

Learn more about each publication at www.aws.org/pubs.com

☐ 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)
☐ Contract construction
☐ Chemicals & allied products
☐ Petroleum & coal industries
☐ Primary metal industries
☐ Fabricated metal products
☐ Machinery except elect. (incl. gas welding)
☐ Electrical equip., supplies, electrodes
☐ Transportation equip. — air, aerospace
☐ Transportation equip. — marine
☐ Transportation equip. — boats, ships
☐ Transportation equip. — railroad
☐ Utilities
☐ Welding distributors & retail trade
☐ Misc. repair services (incl. welding shops)
☐ Educational Services (univ., libraries, schools)
☐ Engineering & architectural services (incl. assns.)
☐ Misc. business services (incl. commercial labs)
☐ Government (federal, state, local)
☐ Other

Job Classification (Check ONE only)
01 President, owner, partner, officer
02 Manager, director, superintendent (or assistant)
03 Sales
04 Purchasing
05 Engineer — welding
06 Engineer — design
07 Engineer — manufacturing
08 Engineer — other
09 Architect
d10 Metallurgist
11 Research & development
12 Quality control
13 Inspector, tester
14 Supervisor, foreman
15 Technician
16 Welder, welding or cutting operator
17 Consultant
18 Educator
19 Librarian
20 Student
21 Customer Service
22 Other

Technical Interests (Check all that apply)
A □ Ferrous metals
B □ Aluminum
C □ Nonferrous metals except aluminum
D □ Advanced materials/Intermetallics
E □ Ceramics
F □ Fiberglass & composites
G □ Aviation
H □ Brazing and soldering
I □ Resistance welding
J □ Thermal spray
K □ Cutting
L □ NDT
M □ Safety and health
N □ Bending and forming
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
10 □ Robotics
2 □ Computerization of Welding

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Member Services Revised 12/21/08

* Plus... Get a popular welding publication for only $25 ($192 value)
March 11
Activity: The St. Louis Section hosted its 8th annual mini welding show at CeeKay Supply Co. in St. Louis, Mo. Representatives from several companies provided demonstrations of the latest welding technology and offered technical expertise. Tully Parker, District 14 director, participated in the event.

March 2
Speaker: John Bruskotter, AWS president
Affiliation: Bruskotter Consulting Services
Topic: Installation of oil and gas platforms in the Gulf of Mexico
Activity: Wayne Burns received the District and Section Meritorious Awards, Rick Guffey earned the District CWI of the Year Award; and Ralph Young was presented the District Educator Award. The event was at Des Moines Area C. C. campus in Ankeny, Iowa, for 70 attendees.

March 4
Speaker: John Bruskotter, AWS president
Affiliation: Bruskotter Consulting Services
Topic: Welding on offshore platforms
Activity: The Section members joined with Wichita Section members for an outing held at Wichita Area Technical College in Wichita, Kan. The event included a tour of the college’s new campus, headed by Sheree Utash, college vice president.

February 11
Activity: Fifty-five Section members met at the Harley-Davidson Motor Co. facility near Kansas City, Mo. Section Treasurer Brian McKee, an engineer with the company, presented an informative talk and conducted a tour of the manufacturing areas.

February 18
Activity: The Section members toured Acuren, Inc., in Duluth, Minn., a materials and weld testing facility. Jerry O’Toole, manager, conducted the program and demonstrated several of the inspection processes.

February 11
Activity: The Section hosted its Behind the Mask welding competition for students and professionals throughout the state of Minnesota. This year, virtual welding and speed cutting contests were added as ways to raise funds for the AWS Anoka Technical College Student Chapter, headed by Advisor Jay Gerdin. The event was held at the college in Minneapolis, Minn. The top scorers included (FCAW) Kory Parchem, Alex Wickstrom, and Steve Swenson; (OFC) Jeremy Hall, Max Bowers, and Carl Holland; and (GTAW) Jeremy Hall, Richard Thorp, and Joe Tonsfeldt.

March 1
Activity: The Section members hosted John Bruskotter, AWS president, for a tour of the welding department at Kirkwood Community College in Cedar Rapids, Iowa. Attending were welding instructors Dan Fitzgerald, Dave Koch, and Dennis Ringgenberg, Industrial Technology Dean Phil Thomas, and Ronald Vallencourt, a welding student.

March 1
Speaker: John Bruskotter, AWS president
Affiliation: Bruskotter Consulting Services
Topic: Installation of oil and gas platforms in the Gulf of Mexico
Activity: Wayne Burns received the District and Section Meritorious Awards, Rick Guffey earned the District CWI of the Year Award; and Ralph Young was presented the District Educator Award. The event was at Des Moines Area C. C. campus in Ankeny, Iowa, for 70 attendees.

February 11
Activity: Fifty-five Section members met at the Harley-Davidson Motor Co. facility near Kansas City, Mo. Section Treasurer Brian McKee, an engineer with the company, presented an informative talk and conducted a tour of the manufacturing areas.
March 3
Speaker: John Bruskotter, AWS president
Affiliation: Bruskotter Consulting Services
Topic: Welding on offshore platforms
Activity: Dennis Wright received the District and Section CWI of the Year Awards. This Kansas City Section program included a barbecue dinner for 35 attendees. The program was held at Hickory Pitt Restaurant in Lees Summit, Mo.

Wichita
March 4
Activity: The Section joined Kansas Section members to meet with AWS President John Bruskotter and David Landon, District 16 director, for a tour of the new campus of Wichita Area Technical College (WATC) in Wichita, Kan. Participating were Sheree Utash, WATC vice president; welding instructors Chet Kemp and Herman Broodryk; and Terry Smith, manufacturing and skill trades learning officer.

District 17
J. Jones, director
(940) 368-3130
jjones@thermadyne.com

Central Arkansas
February 25
Activity: The Section members and welding students participated in demonstrations of the Koike Monograph Millennium CNC plasma cutting machine. The presenters were Scott Stinson of Thermadyne and Chairman Dennis Pickering from Arkansas Career Training Institute. The meeting was held at the institute in Hot Springs, Ark.

North Texas
February 16
Speaker: John Bruskotter, AWS president
Affiliation: Bruskotter Consulting Services  
Topic: Welding on offshore platforms  
Activity: The Section nominated Dwight Grayson for chairman, Bill Hall for vice chair, Chris Wright for treasurer, and Mike Wise for secretary. Among the 93 attendees were Ernest Levert, a past AWS president; Paul Stanglin, scholarship chair; Kirk Jordan, Section chair; and Donnie Williams, a board member.

MARCH 16  
Speaker: Ernest Levert, senior manufacturing engineer and a past AWS president  
Affiliation: Lockheed Martin  
Topic: Welding technologies from around the world  
Activity: This North Texas Section program was held in Arlington, Tex.

OKLAHOMA CITY  
MARCH 10  
Activity: The Section members participated in a hands-on program featuring the Lincoln Vertex 360 virtual welding training equipment. The demonstrators included Adam Webb, Patrick Sagerquist, and Matthew Terell from Lincoln Electric Co. Attendees included students and staff from Caddo-Kiowa Technical Center, Canadian Valley El Reno Campus, Metro Tech South Bryant Campus, and Mid-Del Technology Center, and several local manufacturers and suppliers.

District 18  
John Bray, director  
(281) 997-7273  
sales@affiliatedmachinery.com  

CORPUS CHRISTI  
DECEMBER 10  
Activity: The Section held its Christmas party and awards-presentation program in Corpus Christi, Tex. Cited were Richard
Olympic Section members are shown as Chair Rob Rothbauer (left) presents Rollie Irwin a presenter appreciation plaque during their BMT Northwest tour.

Marslender, Dalton E. Hamilton CWI of the Year Award; Rick Ford, Private Sector Instructor Award; and Mike Mylnar, Section Educator Award. Section Meritorious Awards were presented to Chris Long, Rick Yniguez, and Mike Huelskamp. District 18 Director John Bray and Corpus Christi Chair Ellery Francisco presided.

HOUSTON
January 20
Speaker: Teresa Melfi, R&D dept. manager
Affiliation: The Lincoln Electric Co.
Topic: Calculating heat input using complex waveform power sources
Activity: This awards-presentation meeting also honored the Section’s past chairs. Past chairs in attendance were Jerry Koza Jr., Dennis Eck, Asif Latiff, Rick Keeton, Haskell Ray, Larry Wilmesmeir, and John Bray, currently District 18 director. Don Grubbs received the AWS Life Membership Certificate Award for 35 years of service to the Society.

SAN ANTONIO
January 12
Activity: The Section members met at Hotel Contessa in San Antonio, Tex., to plan for the District 18 conference. Jeremy Huvard, hotel marketing staff hosted the meeting. District 18 Director John Bray attended the meeting.

March 9
Speaker: H. B. Wooten, district manager
Affiliation: Harris Products
Topic: Alternate fuels for the welding industry
Activity: This San Antonio Section program was held at Carino’s Italian Restaurant in San Antonio, Tex. AWS Vice President John Mendoza and more than 30 students attended this meeting.
Albuquerque Section members pose for a group shot during their tour of Mild to Wild Classics.

District 19
Neil Shannon, director
(503) 419-4546
neilshnn@msn.com

OLYMPIC
MARCH 16
Activity: Seventy-five Section members visited BMT Northwest, LLC, in Olympia, Wash., for a tour of the facilities. Rollie Irwin conducted the tour, including the heavy industrial fabrication, structural steel, and steel tank construction areas.

SPOKANE
FEBRUARY 17
Speaker: Jim Gurnea, VP safety services
Affiliation: Associated Industries
Topic: How the brain works
Activity: The program was held at Luigi’s Italian Restaurant in Spokane, Wash.

MARCH
Speaker: Dan Enz
Affiliation: Enzco, Inc.
Topic: Proper handling and hazards associated with welding fuel gases
Activity: The program was held at Oxar Training Center in Spokane, Wash. Following his talk, Enz demonstrated oxyfuel cutting and supervised as attendees tried their hands at the technique.

District 20
William A. Komlos, director
(801) 560-2353
bkoz@arctechllc.com

ALBUQUERQUE
MARCH 11
Activity: The Section members met at Mild to Wild Classics to study their car restoration processes. Tour guides included Tony Kos, Eric Kos, and Tony Kos Jr. Mike Thomas of Rocky Mountain Testing received the Dalton E. Hamilton Memorial District CWI of the Year Award. The Section Meritorious Award was presented to David Drake of Army Technologies. More than 40 members, students, and guests attended.

LONG BEACH/ORANGE CTY.
FEBRUARY 17
Activity: The Section members met at Orange Coast Testing, Inc., in Santa Ana, Calif., for a demonstration of forge welding presented by Leland Means. Paul May spoke about product testing using X-ray and nondestructive testing methods. Paul May and Cynthia Venegas were presented appreciation plaques for hosting the event. Attending were Chair Cary Chiu, Vice Chair Winfred Sartin, and Treasurer Richard Hutchison.

Shown at the Long Beach-Orange County Section program are (from left) Winfred Sartin, Richard Hutchison, Paul May, Cynthia Venegas, and Chairman Cary Chiu.

Leland Means demonstrated forge welding for the Long Beach-Orange County Section.
Attendees at the Sierra Nevada Section program pose for a group shot. Front row (from left), are Jason Rafter (in blue), Dave Kilburn (in red), and Gaylord Rodeman (brown pants).

**District 21**
Nanette Samanich, director
(702) 429-5017
Nan07@aol.com

**District 22**
Dale Flood, director
(916) 288-6100, ext. 172
flashflood@email.com

**SAN FRANCISCO**
**MARCH 3**
Speaker: **Preston Whitney**, sales manager
Affiliation: Therma-Flite
Topic: Technology for a sustainable future
Activity: **Brian Rogers** of Therma-Flite was presented the Section Dalton E. Hamilton Memorial CWI of the Year Award. The program was held at Spenger’s Restaurant in Berkeley, Calif.

**SIERRA NEVADA**
**FEBRUARY 24**
Speaker 1: **Jason Rafter**, Ironworkers Local Union 118 apprentice coordinator
Topic: History of the Ironworkers
Topic: Applications for NR232 and NR233 T-8 flux cored wires
Activity: District 22 Director **Dale Flood** discussed the welding industry and its future prospects. Attending was **Gaylord Rodeman**, advisor for the Regional Technical Institute Student Chapter. The program was held at the Ironworkers building in Reno, Nev.

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McDevitt Receives Student Chapter Member Award

Lakia McDevitt has been selected to receive the Student Chapter Member Award. McDevitt is a member of the AWS Columbian County Career and Technology Center Student Chapter, affiliated with the Mahoning Valley Section, District 10.

McDevitt was chosen by Huck Hughes, Student Chapter advisor, to receive the award. She is a member of the National Technical Honor Society and will graduate with a 3.8 grade point average. She has served as the Chapter’s 2008-09 treasurer and as chairperson, she attended all of the Mahoning Valley Section meetings and events.

The AWS board of directors established the Student Chapter Member Award to recognize AWS Student Members whose Student Chapter activities have produced outstanding school, community, or industry achievements. This award also provides an opportunity for Student Chapter advisors, Section officers, and District directors to recognize outstanding students affiliated with a Student Chapter, as well as to enhance the image of welding within their communities.

For more information about this award, visit www.aws.org/sections/awards/student_chapter.pdf, or call the Membership Dept. (800) 44309353, ext. 260.

Bray Named AWS Distinguished Member

John R. Bray, District 18 director and a member of the Houston Section, has attained the status of Distinguished Member for his outstanding service to the Society.

To qualify for distinguished membership status, applicants must accrue 35 points or more from these four categories: national AWS leadership, local AWS leadership, professional development, and AWS membership recruitment. If you believe you qualify for distinguished membership, contact the Membership Department, (800) 443-9353 ext. 260.

John R. Bray
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- The Welder’s Exchange bulletin board on the AWS web site
- and more...

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Visit: www.aws.org/membership

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Conference Program

Recent Developments and Novel Applications of Solid State Joining Techniques
Mike Russell / TWI Ltd. / Cambridge, UK

Hybrid Laser Arc Welding Provides Numerous Advantages
Paul Blomquist / Applied Thermal Sciences, Inc. / Sanford, ME

Computer Radiology – Innovations for Film Quality Results in Industrial Applications
Terry Plasek / Fujifilm NDT Systems / Conroe, TX

The Application of Deformation Resistance Welding for Tubular Products
Brian Finnigan / SpaceForm Welding Solutions / Madison Heights, MI

Thermal Stir Welding (TSW) and Ultrasonic Stir Welding (USW) Processes for Solid State Welding Applications
Jeff Ding / NASA Marshall Space Flight Center / Huntsville, AL

Cladding and Additive Manufacture Using Laser Applied Powder (LAPTM) Processes
Scott Poeppel / Joining Technologies, Inc. / East Granby, CT

Automated Weld Seam Facing Tools Modified to Also Perform Back Gouging
Bruce Horn / Navy Metal Working Center / Concurrent Technologies Corporation / Johnstown, PA

Dual Hot Wire/Cold Wire Gas Tungsten Arc Cladding Procedure Developed to Significantly Improve Deposition Rate
Bruce Horn / Navy Metal Working Center / Concurrent Technologies Corporation / Johnstown, PA

Fiber Lasers: The Flexible Tool for High Power Laser Welding
Eric Stiles / IPG Photonics / Novi, MI

Monitoring the New High Tech Version of Heat Treatment
Gary Lewis / Superheat FGH / Mooresville, NC

Controlled Short Circuit GMAW Process Surpasses SMAW and GTAW for Productivity, Ease-of-Use, Cost Effectiveness on Root Pass Pipe Welding
Jim Cuhel / Miller Electric Mfg. Co. / Appleton, WI

DeltaSpot – A Perfect Solution to Weld Aluminum: Resistance Spot Welding with Process Tape
Stefan Mayr / DeltaSpot FRONIUS USA LLC / Brighton, MI

A New Hybrid Plasma-GMA Welding Process Features Many Advantages Over GMAW
Brian Finnigan / SpaceForm Welding Solutions / Madison Heights, MI

Induction Heating Provides Improved Productivity, Ease of Use and Lower Costs Compared to Conventional Heating in Welding Projects
Al Sherrill / Miller Electric Mfg. Co. / Appleton, WI

Recent Developments in Ultrasonic Additive Manufacturing (UAM)
Matt Short / Edison Welding Institute / Columbus, OH

For more information on attending the conference or exhibiting please visit www.aws.org or call 800-443-9353 ext. 462
Industrial Cables for Green Energy Pictured

The 160-page Industrial Cable Catalog illustrates and describes a wide variety of portable cord, industrial power cables, instrumentation cables, tray cables, and lead wire, plus custom cables designed for the green energy and emerging markets. Information is provided on thermoplastic elastomer (Seoprene® SEO), thermoset (Royal® SOO), and polyvinyl chloride constructions to meet various engineering requirements. Included for the first time is the Copperfield® brand line of UL/CSA appliance, SAE automotive, military, and industrial lead wires.

Coleman Cable, Inc.
www.colemancable.com
(800) 323-9355

Free Thermoplastic Laser Welding Tutorial Offered

A 224-page catalog features the Decontactor Series switch rated plugs, receptacles, and connectors that allow technicians to quickly change out welding machines, motors, and other electrical equipment. Information is provided about other plug and receptacle product offerings including new hazardous-duty-rated devices, PF high-current devices (up to 600 A), and a wide variety of multipin devices, with up to 37 contacts. The line is UL approved for both branch circuit and motor circuit disconnect switching up to 200 A or 60 hp, and to withstand short circuits up to 100 kA. Also detailed are the extensive applications for the products and their safety-enhancing features.

Meltric Corp.
www.meltric.com
(800) 433-7642

New Interactive Production Systems Catalog Launched

The company has released its Manual Production Systems Catalog, version 3.0, in both print and a new interactive online version. The online catalog makes it easier to navigate, see zoom-in views of products, search by name or part number, and print only the pages of interest. The products offered provide tailored solutions for driving, controlling, and moving machinery used in industrial and factory automation, as well as in mobile applications. The products simplify the construction of custom workstations, material shuttles, or flow racks for an easy-to-use lean manufacturing design system with minimum wasted space and ergonomic principles built-in to optimize working conditions. Call or visit www.boschrexroth-us.com to order the printed catalog. The interactive catalog can be accessed at the Web site shown below.

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North American Die Casting Assn.
www.diecasting.org/technology/archive/
(847) 279-0001

5000 Aluminum Extrusions White Paper Released

The company has released a white paper titled, 5000 Series vs. 6000 Series Aluminum Extrusions, intended to serve as an education tool for marine and military applications, that details the unique attributes of its 5000 series aluminum extrusions and why they have become such valuable components for the U.S. military. Described are the many uses of the alloy extrusions in marine and military vehicle applications and its numerous advantages over the more common 6000 series soft alloys. A chart lists maximum and minimum ultimate and yield tensile strengths and elongations for 12 alloy/temper and strength data for extruded wire, rod, bar. The five-page paper can be downloaded from the Web site shown below.

Taber Extrusions LLC
http://tinyurl.com/TaberExtrusionsWhitePaper
(800) 563-6853

Guide Offered for Energy Professionals

The free, 28-page, well-illustrated The Energy Professional’s Guide to Data Loggers & Building Performance, is written for measurement and verification practitioners, commercial energy auditors, and building commissioners. It details how portable data loggers can be applied in a number of building-monitoring applications, such as heating, ventilating, air-conditioning (HVAC) systems monitoring, commissioning, measurement and verification, and load profiling. Practical tips and techniques are offered on a range of topics, including data logger installation, monitoring plan development, safety, and data interpretation. Detailed are energy and environmental monitoring products that can be rapidly deployed in a broad range of applications including energy audits and indoor air-quality studies. The guide can be downloaded as a PDF from the Web site shown below.

Onset Computer Corp.
www.onsetcomp.com/epg
(800) 564-4377

Aluminum Design Manual Updated for 2010

The Aluminum Design Manual is written for all professionals who work with aluminum in structural applications. Included are numerous topics including safety, design for stability and combined stresses, shear yield strength, screw slot pull-out strength, evaluating existing structures, axial compressive strength of complex cross sections, fatigue strength of light pole bases, members subject to torsion, local buckling strength of welded elements, design for fire conditions, and design of braces. The manual is available in book and CD-ROM formats. Each format is priced at $295 list, $250 for association members, plus shipping. To order, visit the Web site shown, and click on the “What’s New” tab.

The Aluminum Association, Inc.
www.aluminum.org/bookstore
(703) 358-2960

Weld Purging Videos Posted for Online Viewing

Visit the Web site to view a number of two- to five-minute-long videos demonstrating various weld purging products of — continued on page 101
Twarog Receives Die Casting Award

The Advanced Casting Research Center at Worcester Polytechnic Institute, Worcester, Mass., has presented its Ray H. Witt Award to Daniel Twarog for his leadership in the aluminum casting industry. Twarog, with 30 years’ experience in the field, has received numerous awards for his research work in investment casting technology, lost foam emission characterization, tramp element effects in aluminum, and other areas. He has served as president of the North American Die Casting Association, Wheeling, Ill., since 1999.

Mapes Elected to Lincoln Electric Board

Lincoln Electric Holdings, Inc., Cleveland, Ohio, has elected Christopher L. Mapes to its board of directors. Mapes is executive vice president of A. O. Smith Corp., and president of its Electrical Products unit. His election brings the number of board members to eleven.

Trinity Industries Appoints Two Corporate Officers

Trinity Industries, Inc., Dallas, Tex., has elected Antonio Carrillo vice president and Jared S. Richardson secretary and associate general counsel. Carrillo, with the company since 1996, most recently served as group president of the Energy Equipment Group. He retains responsibility for the company’s operations in Mexico. Richardson previously was senior counsel and assistant secretary for Energy Future Holdings Corp.

CEO Named at Genesis Plastics Welding

Genesis Plastics Welding, Indianapolis, Ind., a contract manufacturer of radio-frequency (RF) welded thermoplastic products, has promoted Tom Ryder to chief operating officer. Ryder, a member of the company’s board of directors, previously oversaw the company’s sales, marketing, product development, and customer service operations.

SME Appoints Membership Director

The Society of Manufacturing Engineers (SME), Dearborn, Mich., has named Joe LaRussa director of membership. He succeeds Debbie Holton who now serves as director of industry strategy and product development. Before joining the society, LaRussa, a long-time SME member, worked as project manager, customer quality office, for Chrysler Group, LLC.

Harris Selects Director of National Accounts

The Harris Products Group, Mason, Ohio, a Lincoln Electric Co., has appointed Lorie Plengemeier director of national accounts. Previously, Plengemeier served at Thermadyne for ten years in various leadership positions, most recently as national accounts manager.

Obituary

Joseph H. Dillhoff

Joseph H. Dillhoff, 53, died Feb. 28 in Cincinnati, Ohio. Dillhoff, an AWS member since 1994, served as president of OKI Bering, a family-owned company, for nearly 17 years. He participated on the AWS Finance Committee and was a member of the Welding Equipment Manufacturers Committee (WEMCO), an AWS standing committee, and the AWS Publications, Expositions, Marketing Committee (PEMCO). He also served as a board member of Gases and Welding Distributors Association (GAWDA). Dillhoff served on the President’s Advisory Board of Xavier University and as a mentor for Williams College of Business. He attended St. Xavier High School and received his master’s in business administration from Xavier University. He is survived by his wife, Connie, his parents, a son and daughter, three sisters, and 19 nieces and nephews.

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Plasma Cutting Technology Presented in Online Video

The first in a planned series of informational videos is hosted by Andrew Masterman, company president and CEO. It discusses and demonstrates the latest innovations in plasma cutting technology for mechanized cutting applications. Included are new water-injection technology with the capability to combine water injection and gas shielded cutting on the same gantry. The video can be viewed on the Web site shown below.

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Brochure Highlights Magnetic and Separation Equipment

The four-page, full-color Equipment for the Metalworking Industry catalog showcases the company’s magnetic and separation equipment designed for the metalworking industry. Readers can easily determine the equipment best suited for each project using a table that matches a wide variety of specific metalworking applications with appropriate equipment. Highlighted are magna rolls, sheet faners, vibratory feeders, chip and parts conveyors, lifting magnets, belt conveyors, coolant cleaners, liquid line traps, and grate magnets. The catalog can be downloaded from the Web site shown, or call for a copy by mail.

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NEW LITERATURE — continued from page 99

particular interest to pipe fabricators. Topics include inflatable tandem purge dams, single purge dams, a weld gas analyzer, and the patented Quick Purge instruments. Each video explains the areas of use for the products and how they can save money and time for fabricators of stainless steel and titanium. Several advantages include improved weld quality, increased production rates, and reduced welding costs.

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COMING EVENTS — continued from page 66

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NDE and CWI/CWE Courses and Exams. Allentown, Pa., and at customers’ locations. Call Welder Training and Testing Institute, (800) 223-9884, or visit www.wtti.edu.


Protective Coatings Training and Certification Courses. At various locations and online. Call The Society for Protective Coatings (877) 281-7772, or visit www.sspc.org.
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<td>800-443-9353</td>
<td><a href="http://www.aws.org">www.aws.org</a></td>
</tr>
<tr>
<td>AWS Conference Services</td>
<td>.63, 68, 96</td>
<td><a href="http://www.aws.org/conferences">www.aws.org/conferences</a></td>
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<tr>
<td>AWS Member Services</td>
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<td>AWS Technical Services</td>
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<td><a href="http://www.awspubs.cn">www.awspubs.cn</a></td>
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<tr>
<td>Bellingham Technical College</td>
<td>.360-752-7000</td>
<td><a href="http://www.btc.ctc.edu">www.btc.ctc.edu</a></td>
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<tr>
<td>Bohler Welding Group USA, Inc.</td>
<td>800-827-0791</td>
<td><a href="http://www.btwusa.com">www.btwusa.com</a></td>
</tr>
<tr>
<td>Bruker AXS</td>
<td>978-439-9899</td>
<td><a href="http://www.handheldxrf.com">www.handheldxrf.com</a></td>
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<tr>
<td>CM Industries, Inc.</td>
<td>.847-550-0033</td>
<td><a href="http://www.cmindustries.com">www.cmindustries.com</a></td>
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<tr>
<td>Commercial Diving Academy</td>
<td>888-974-2232</td>
<td><a href="http://www.commercialdivingacademy.com">www.commercialdivingacademy.com</a></td>
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<td>.810-227-3251</td>
<td><a href="http://www.cor-met.com">www.cor-met.com</a></td>
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<td>.805-498-3837</td>
<td><a href="http://www.diamondground.com">www.diamondground.com</a></td>
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<td>Divers Academy International</td>
<td>800-238-3483</td>
<td><a href="http://www.diversacademy.com">www.diversacademy.com</a></td>
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<td>ESAB Welding and Cutting Products</td>
<td>.800-372-2123</td>
<td><a href="http://www.esabna.com">www.esabna.com</a></td>
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<td>FABTECH</td>
<td>.800-443-9353, ext. 297</td>
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<td>Fischer Engineering Company</td>
<td>937-754-1750</td>
<td><a href="http://www.fischerengr.com">www.fischerengr.com</a></td>
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<td>Fronius Perfect Welding</td>
<td>.810-220-4414</td>
<td><a href="http://www.fronius-usa.com">www.fronius-usa.com</a></td>
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<td>Greiner Industries, Inc.</td>
<td>.800-782-2110</td>
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Effects of Baking on the Structure and Properties of Resistance Spot Welds in 780 MPa Dual-Phase and TRIP Steels

The effects of baking treatments on weld microstructure and mechanical properties are explained through TEM analysis

BY M. TUMULURU

ABSTRACT

Dual-phase and transformation-induced plasticity (TRIP) steels are finding increased application worldwide in car and truck bodies due to the many advantages they offer. These structures are typically joined by the resistance spot welding process. Subsequently, the welded car bodies and frames are painted and undergo an elevated-temperature paint baking process. Because the effect of baking treatments on weld microstructures and mechanical properties was not known, a systematic study was undertaken to evaluate the effect of paint baking on the tensile-shear strength and microstructure of resistance spot welds in 780 MPa dual-phase and TRIP steels. Peel tests, shear-tension tests, and microhardness traverses were conducted on the as-welded (nonbaked) and baked weld samples. Both as-welded and baked welds were examined using both a scanning (SEM) and a transmission (TEM) electron microscope. The results showed that postweld baking increased the load-bearing ability of the welds in shear-tension tests compared with that of the samples in the as-welded condition. However, for both steel grades, baking had no effect on the fracture appearance in shear-tension tests, as expected, and no noticeable changes were observed in weld hardness. TEM examination revealed that, in both the TRIP and the dual-phase steels, the dislocation density in the ferrite and on ferrite grain boundaries was low in the base or matrix material, but much higher in the heat-affected zone (HAZ) and the weld fusion zone, and large areas of lath and twin martensite were found, along with ferrite, in the weld. Epsilon (ε) carbide precipitates were found in twin martensite regions of the weld and HAZ regions in both the dual-phase and the TRIP steels after baking. It is believed that baking introduced Cottrell atmospheres around dislocations and grain boundaries, and thus changed the local yielding behavior, which was manifested in the small increase in shear-tension strength. Further, the low-temperature tempering from the baking treatment caused precipitation of transition (ε) carbides in the martensite within the weld and the HAZ, and is believed to have resulted in a certain amount of toughening within these microstructures.

KEYWORDS

Resistance Spot Welds
Baking
TRIP Steels
Dual-Phase Steels
Transmission Electron Microscopy
Shear Tension Test
Microhardness

Increasingly finding use in automotive applications.

The methods of production of TRIP and dual-phase steels are shown schematically in Fig. 1. In the case of TRIP steel, when the steel is heated into the intercritical temperature range for annealing, dissolution of cementite occurs and formation of austenite starts. This leads to a microstructure consisting of a mixture of austenite and a matrix of ferrite. Holding time and temperature determine the proportion of each phase. Generally, a phase distribution of 30% austenite and 70% ferrite is aimed for at the end of intercritical annealing. The annealing temperature may range from 770° to 850°C. Then, in the next phase, cooling takes place and is interrupted at 400°C. This leads to isothermal transformation to low-carbon bainite and carbon-enriched austenite. The final microstructure consists of low-carbon bainite and a carbon-enriched austenite in a ductile ferrite matrix and some martensite. The retained austenite transforms to martensite when stress is applied during forming. This transformation is diffusionless and gives improved ductility. Silicon, aluminum, and phosphorus are added to the steel to retard cementite formation and help enrich austenite in carbon (Ref. 3). The production of dual-phase steel is similar to that of TRIP steel except that the steel is alloyed and cooled from the intercritical temperature range in such a way as to avoid the formation of bainite. The final microstructure consists of ferrite and martensite. The room-temperature microstructures of both the steels are shown in Fig. 2.

Both dual-phase and TRIP steels can be coated with zinc or zinc-iron for automotive applications. The pure zinc coating is called galvanized coating and the zinc-iron alloy is called galvannealed coating. The term "galvanize" comes from the galvanic protection that zinc provides to steel substrate when exposed to a corroding medium. A galvan-
neal coating is obtained by additional heating of the zinc-coated steel at 450° to 550°C (840° to 1020°F) immediately after the steel exits the molten zinc bath. This additional heating allows iron from the substrate to diffuse into the coating. Due to the diffusion of iron and alloying with zinc, the final coating contains around 90% zinc and 10% iron. These two coatings are applied through a hot-dipping process. These coated steels are welded in automotive applications predominantly using the resistance welding process.

In automobile production, welded car bodies (body-in-white) go through painting, at which time they are baked at elevated temperature. Paint baking of automobile bodies involves multiple baking treatments typically at temperatures in the vicinity of 150°C. The time of baking may range from 20 to 30 min.

Earlier work on some of the advanced high-strength steels (AHSS), such as hot-dipped galvannealed 780 TRIP and hot-dip galvannealed 590 dual-phase steel, showed a beneficial effect of baking on fracture appearance in spot weld peel tests (Ref. 4). Many of the baked welds in these steels showed full button pull out in peel tests whereas, prior to baking, they exhibited predominantly partial weld breaks. Other reported benefits of postweld baking TRIP and dual-phase steels include increased weld ductility and energy-absorption in impact tests (Ref. 5). However, at present there is no clear understanding of the fundamental mechanism by which baking influences the weld properties, hence weld performance. In order to examine the effect of baking on spot weld behavior, a study was undertaken on the effects of baking on resistance spot welds in 780 MPa TRIP and dual-phase steels. The study involved the examination of the tensile properties and the microstructure of welds in the nonbaked condition (referred throughout the document as “as-welded” samples) and the baked condition to see what, if any, changes occurred from the baking treatment. The 780 MPa TRIP and dual-phase steels were chosen for the study because the resistance spot welding behavior of these two steels was found to be similar (Ref. 6). Further, these two steel grades are increasingly being used in current automobile manufacture worldwide.

**Materials and Procedures**

The samples for this study came from coils of 780 MPa dual-phase and TRIP steel that were melted, hot and cold rolled at United States Steel Corp. Gary Works, and subsequently coated at PRO-TEC Coating Co. of Leipsic, Ohio. Both of the dual-phase and TRIP steel samples were 1.6 mm thick. All weld testing was carried out on samples in the as-received condition without any cleaning of the mill oil. Typically, both steel grades contain around 0.1 to 0.2 wt-% carbon and are generally alloyed with various amounts of hardening agents such as manganese, chromium, and molybdenum (Refs. 7–9). In addition to these alloying elements, TRIP steels typically contain silicon or aluminum to effectively suppress the formation of cementite by increasing the time required for its formation and lowering its thermodynamic

**Table 1 — Typical Mechanical Properties of Steels Used**

<table>
<thead>
<tr>
<th>Steel Grade</th>
<th>Thickness, mm</th>
<th>Yield Strength, MPa</th>
<th>Ultimate Tensile Strength, MPa</th>
<th>Elongation, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRIP</td>
<td>1.6</td>
<td>433</td>
<td>800</td>
<td>24.1</td>
</tr>
<tr>
<td>Dual Phase</td>
<td>1.6</td>
<td>480</td>
<td>810</td>
<td>18</td>
</tr>
</tbody>
</table>

**Table 2 — Welding Equipment Details**

<table>
<thead>
<tr>
<th>Welding Machine Manufacturer</th>
<th>Taylor Winfield Corp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding Machine Type</td>
<td>Pedestal</td>
</tr>
<tr>
<td>Welding Machine Transformer</td>
<td>100 kVA</td>
</tr>
<tr>
<td>Welding Controller</td>
<td>TruAmp IV (constant current type)</td>
</tr>
<tr>
<td>Electrode Coolant Water Temperature</td>
<td>21°C</td>
</tr>
<tr>
<td>Tip Cooling Water Flow Rate</td>
<td>3.7 L (1 gal)/min minimum</td>
</tr>
</tbody>
</table>

**Table 3 — Welding Conditions**

<table>
<thead>
<tr>
<th>Electrode Face Diameter</th>
<th>7.0 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrode Force</td>
<td>8 kN</td>
</tr>
<tr>
<td>Electrode Tip Geometry</td>
<td>Truncated Cone</td>
</tr>
<tr>
<td>Squeeze Time</td>
<td>75 cycles</td>
</tr>
<tr>
<td>Weld Time</td>
<td>18 cycles</td>
</tr>
<tr>
<td>Hold Time</td>
<td>10 cycles</td>
</tr>
<tr>
<td>Preheating</td>
<td>None</td>
</tr>
<tr>
<td>Postheating</td>
<td>None</td>
</tr>
</tbody>
</table>
stability (Ref. 8). Typical tensile properties of steels used in this study are shown in Table 1. Both the steels were hot-dipped galvannealed with a nominal coating weight of 42/42 g/m² (42 g/m² per side). This coating weight is typical of current commercial automotive use.

The details of the welding equipment used for making the test welds are shown in Table 2. The welding conditions used to prepare the spot weld samples are shown in Table 3. These conditions were determined after making several welds to ascertain good nugget profiles. The welding electrodes used were RWMA Class II with truncated cone tip geometry. Prior to preparing the test welds, the electrode tips were conditioned using the procedure described in Ref. 10.

The baking cycle used for the welds in this study involved heating the samples at 150°C for 30 min twice followed by 20 min at 95°C. This bake cycle was chosen based on the author's discussions with representatives of various automotive companies and it represented the typical paint baking cycle used in the automotive industry. To determine the effect of baking on the behavior of the resistance spot welds, the following tests and examinations were performed: 1) shear-tension tests, 2) scanning electron microscope examination, 3) transmission electron microscopic examination, and 4) examination of weld microhardness profiles. All these tests were done on weld samples both in the as-welded (unbaked) and baked conditions. The results from the baked samples were compared to those obtained from the as-welded samples.

Weld shear-tension tests were conducted per Ref. 10. A schematic of the shear-tension test coupon is shown in Fig. 3. The weld size in the tensile samples was 90% of the face diameter of the electrode tip used. The current required to produce the required weld size (6.3 mm) was determined prior to preparing the tensile samples. This was done using the highest current possible without causing expulsion in the welds. After the test, weld samples were examined to determine the mode of fracture. Microhardness traverses were determined at room temperature using a Vickers hardness tester. A force of 9.8 Newtons was used for the microhardness measurements. The hardness indentations were spaced 0.4 mm apart. The microhardness traverses were done on a diagonal to cover as much area in the weld and heat-affected zones (HAZs) as possible. Cross sections of weld microstructures were examined using both an optical microscope and a scanning electron microscope (SEM).

The base material, HAZ edge, and HAZ center are indicated in Fig. 4. For the TEM study, conventional thin foils were prepared from the weld samples. The locations from which the foils were extracted are shown in Fig. 4. First, 0.2- to 0.5-mm-thick sheet sample pieces were obtained from selected sampling locations using a low-speed diamond-coated cutting wheel. Each sample was subsequently thinned mechanically (e.g., using 180- to 600-grit carbide grinding paper) to a thickness of 0.1 to 0.15 mm.

In order to remove any dislocations that could have been introduced during mechanical grinding, the 0.1-mm sheet samples were further thinned by chemical polishing with two separate solutions. The first solution consisted of 50 mL distilled water, 50 mL HNO₃, 15 mL HCl, and 10 mL HF. The final thickness of each sheet sample after chemical polishing was 0.06 to 0.08 mm.

Discs with a diameter of 3 mm were punched from the center-most region of the 0.06- to 0.08-mm-thick sheet samples. These discs were further thinned by electrolytic twin-jet polishing at room temperature. The electrolyte consisted of an average of 90% (typically 85 to 95%) acetic acid and an average 10% (typically 5 to 15%) perchloric acid. Polishing was done at 40 to 80 V DC and a current of 25 to 50 mA. The polish was stopped automatically when the optical sensor in the polisher detected a hole in the center of the foil. The sensitivity of the sensor and the alignment of the twin-jets, sensor and foil can affect the size of the hole. Typical polishing times were generally in the range of 3 to 4 min. Immediately after disc perforation, the holder and sample were removed from the polisher and immersed in ethanol to remove any electrolyte residue.

The TEM samples were analyzed using a JEOL Ltd. JEM-200CX transmission electron microscope (TEM) and JEOL Ltd. JEM 2000FX STEM (scanning transmission electron microscope) both operated at 200 kV. Dislocation densities were estimated by measuring the total projected length of dislocation lines in a given area.
of a micrograph. Typical areas were selected in the electron micrograph assuming that the dislocation segments are randomly oriented (isotropic distribution of dislocations). The average true length of dislocation line $R$ can be derived from the average projected length through the foil, $R_p$, by using the relation

$$R = \frac{4}{\pi} R_p,$$

where $R_p = \pi NA/(2L)$, $A$ is the projected area of the foil containing the dislocation line, and $N$ is the number of intersections with dislocations by random lines of length $L$.

The dislocation density is then given by

$$\rho = \frac{R}{(At)} = \frac{2N}{Lt}$$

where $t$ is the thickness of the foil, estimated from diffraction condition and extinction fringes, usually from 50 to 200 nm (Ref. 11). At least seven fields of view were used per sample to measure the dislocation densities. Precision involved in the data is ± 20%.

## Results

The results of the shear-tension tests for both as-welded and baked samples are shown in Table 4. The standard deviation for the test data in shear-tension testing of dual-phase steel was 196 Newtons and that for the TRIP steels was 240 Newtons. It is apparent from Table 4 that postweld baking increased the maximum load that the welds took prior to fracture. This indicates that both TRIP and dual-phase steels have noticeable “bake hardening” effect. One consequence of baking appeared to be an increase in the load-carrying ability of the welds. Examination of the fracture appearance of the samples indicated that, while most of the as-welded and baked weld tensile samples in the TRIP steel broke interfacially (across the weld interface), most of the as-welded and baked weld samples in the dual-phase steel broke with a full button pull out (separation of the button from one of the sheets leaving the weld intact). Examples of full button pullout and interfacial fracture modes are shown in Fig. 5.

Examination of Table 4 indicates that the maximum load taken by the TRIP steel samples prior to failure was quite high. From this, it is apparent that despite interfacial fractures in tensile tests, the welds performed quite satisfactorily in the tensile tests. This demonstrated that interfacial mode of fracture of welds does not indicate poor weld performance in these high-strength steels.

Microhardness profiles for welds in TRIP and the dual-phase steels in the as-welded and baked condition are shown in Fig. 6. Examination of the microhardness profiles indicated that no significant differences in hardness existed between the as-welded and baked welds. In fact, the difference in the average weld area hardness between the baked and as-welded samples was about 3 HVN, which is smaller than the typical scatter seen in hardness testing.

The SEM examination of the samples showed that the weld microstructures in the as-welded condition consisted of...
martensite in both TRIP and dual-phase steels. The SEM micrographs from the weld areas are shown in Fig. 7. In the baked condition, faint evidence of tempering of the martensite was seen in the dual-phase steel from the SEM examination but the structure could not be clearly resolved. In the heat-affected zone, both steels showed predominantly martensite.

Table 5 — Summary of TEM Microstructural Characterization Results

<table>
<thead>
<tr>
<th>Grade</th>
<th>Location and Condition</th>
<th>Retained Austenite</th>
<th>Ferrite</th>
<th>Twin Martensite</th>
<th>Lath Martensite</th>
<th>Tempered Martensite</th>
<th>Bainite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Material</td>
<td>Low</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Not Observed</td>
<td>Not Observed</td>
<td>Not Observed</td>
</tr>
<tr>
<td>HAZ, As-Welded</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>High</td>
<td>Yes</td>
<td>Yes</td>
<td>Not Observed</td>
</tr>
<tr>
<td>DP</td>
<td>Weld Fusion Zone, As-welded</td>
<td>Yes</td>
<td>Yes</td>
<td>High</td>
<td>Yes</td>
<td>Yes</td>
<td>Not Observed</td>
</tr>
<tr>
<td>HAZ, Baked</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>High</td>
<td>Yes</td>
<td>Yes</td>
<td>Not Observed</td>
</tr>
<tr>
<td>Weld Fusion Zone, Baked</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>High</td>
<td>Yes</td>
<td>Yes</td>
<td>Not Observed</td>
</tr>
<tr>
<td>Base Material</td>
<td>Low</td>
<td>Yes</td>
<td>Yes</td>
<td>Low</td>
<td>Yes</td>
<td>Not Observed</td>
<td>Not Observed</td>
</tr>
<tr>
<td>HAZ, As-Welded</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>High</td>
<td>Yes</td>
<td>Yes</td>
<td>Low</td>
</tr>
<tr>
<td>TRIP</td>
<td>Weld Fusion Zone, As-welded</td>
<td>Yes</td>
<td>Yes</td>
<td>High</td>
<td>Yes</td>
<td>Yes</td>
<td>Low</td>
</tr>
<tr>
<td>HAZ, Baked</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>High</td>
<td>Yes</td>
<td>Yes</td>
<td>Low</td>
</tr>
<tr>
<td>Weld Fusion Zone, Baked</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>High</td>
<td>Yes</td>
<td>Yes</td>
<td>Low</td>
</tr>
</tbody>
</table>

Note: The weld zone microstructures in the as-welded and baked conditions for both DP and TRIP steels were similar to those in the HAZ regions of the respective steels.
with small areas of ferrite and bainite — Fig. 8. In fact, martensite was seen in the entire width of the HAZ. In the baked condition, some of the carbides appeared to be more spherical; however, resolution was lacking in the SEM.

TEM results for weld and HAZ microstructures in both dual-phase and TRIP steels appeared to be consistent with those obtained from the SEM examination. Both the weld and the near HAZs showed similar microstructure, which consisted of predominantly martensite. The HAZ, which was narrow, showed areas of ferrite, and small scattered regions of tempered martensite. Various microstructural constituents revealed through the TEM examination are summarized in Table 5. It
should be pointed out that TEM is not an appropriate tool for quantitative estimation of microstructural constituents because of the very small regions it typically provides for examination. Therefore, the term “high” in Table 5 is meant to indicate, in qualitative terms, that large areas of a particular microstructural constituent were observed in several of the foils examined. The term “yes” is meant to indicate noticeable presence, whereas the term “low” indicates that only isolated, scattered small areas of a specific microstructural constituent were observed. It should also be pointed out that dislocation density measurements were not attempted in the martensite regions due to the presence of high-dislocation density and the difficulty in resolving the fine substructure.

Some of the key TEM observations of the weld samples for both the steels are summarized below.

1) The base material of 780DP steel has martensite-austenite (M-A) constituent, sometimes along certain ferrite boundaries. At higher magnifications, the structure showed that the M-A island contained mainly twin-martensite (bundles of 5- to 7-nm-thick plates), plus some retained austenite. The ferrite region had a low dislocation density of about 3 to 7 x 10^10/cm^2. Figure 9 shows the TEM micrographs obtained from the 780DP base material.

2) The 780DP HAZ and weld regions in the as-welded sample showed mainly twin martensite, with isolated small areas of lath martensite, tempered martensite, and retained austenite. As the sampling region moved away from the weld interface boundary, more ferrite grains were observed, where the dislocation density ranged from 4 x 10^10/cm^2 to 3 x 10^11/cm^2.

3) The 780DP HAZ and weld regions in the baked condition showed similar overall microstructure as the as-welded condition. The overall dislocation densities were similar to those in the as-welded samples. Further, epsilon carbides (ε) were observed in some twinned martensite regions of the baked weld.

4) The microstructure of 780TRIP base metal consisted of ferrite, austenite, M-A, and bainite, with more retained austenite and more twinned martensite than in the DP steel. The dislocation structure in ferrite was similar to that in DP base material. Representative microstructures from 780TRIP base metal are shown in Fig. 10.

5) In the as-welded samples in 780TRIP, the HAZ and the weld regions contained mainly twin martensite, with areas of retained austenite. As the sampling region moved away from the weld interface, more tempered martensite and ferrite grains were observed. As with the DP steel, the dislocation density in ferrite ranged from 4 x 10^10/cm^2 to 3 x 10^11/cm^2. Figure 11 shows a TEM micrograph of the HAZ in 780TRIP steel.

6) The baked 780TRIP HAZ and weld regions showed similar overall microstructures with the dislocation densities similar to those in the as-welded samples. Some of the major microstructural constituents of the HAZ in the baked condition are shown in Fig. 12. Further, as with the DP steel samples, epsilon carbides were ob-
served in some twinned martensite regions, indicating decomposition of twin martensite during the baking process. A TEM micrograph of epsilon carbide precipitation from twin martensite regions in 780DP steel is shown in Fig. 13.

**Discussion**

**Fracture Mode Differences**

There are two different failure modes that are generally observed in shear-tension tests, namely, “interfacial fractures” or “full button pull out.” In the interfacial failure, the weld fails at the interface of the two sheets, leaving half of the weld nugget in one sheet and half in the other. In the full button pull out, failure occurs in the weld HAZ around the weld nugget. In this failure mode, the weld nugget is completely torn from one of the sheets with the weld remaining intact. It is also possible to get a combination of the two failure modes in which a portion of the nugget is pulled out of one of the sheets and the rest of the nugget shears at the interface.

The occurrence of interfacial fractures in shear-tension tests has historically been seen to be indicative of poor weld integrity. This has typically been true for low-strength steels (tensile strength ≤ 300 MPa), in which interfacial failure is normally associated with insufficient fusion or some sort of a weld imperfection, such as gross porosity. However, recently it was shown that for sheet thickness around 1.6 mm in dual-phase and TRIP steels both interfacial and full button pull-out fracture modes are possible. Further, above 1.6-mm sheet thickness interfacial fractures are the expected mode of failure (Ref. 12). Thus, the sheet thickness used in this study represents a transition between full button pull out and interfacial fracture modes. The results reported here are consistent with earlier analyses of the expected fracture modes in shear-tension tests of 780 MPa DP and TRIP steels (Ref. 12). The present results showed that the occurrence of interfacial fractures do not degrade the load-bearing ability of the 780 MPa TRIP and dual-phase steels.

**Microstructural Changes**

Both SEM and TEM examinations revealed that the major microstructural constituents in the HAZ as well as the weld fusion zone were similar for both the steels. The HAZ and the fusion zones showed a predominantly martensitic microstructure with areas of ferrite, followed by small areas of retained austenite, tempered martensite, and a few isolated areas of bainite. Similar microstructural results were reported by Khan et al. for resistance spot welds in dual-phase and TRIP steels (Ref. 13). In resistance spot welding, due to the water cooling of the electrodes, the weld cooling rates are extremely rapid. Spot welds in thicknesses up to 2 mm typically solidify in less than 55 to 65 ms (Ref. 14). It has been shown through modeling that even at 500°C the cooling rates in spot welding were in excess of 1000°C/s (Ref. 14). For steels, the critical cooling rate, v, required to achieve martensite in the microstructure is given by the following equation:

\[
\log v = 7.42 - 3.13 C - 0.71 Mn - 0.37 Ni - 0.34 Cr - 0.45 Mo \quad \text{(Ref. 15)}
\]

For the 780 MPa dual-phase steel used here, the critical rate turns out to be about 240°C/s. This means a predominantly martensitic structure is expected both in the weld and the HAZ for both steels.

The TEM analysis indicated that various microstructures present in the weld and the HAZ include predominantly martensite, followed by ferrite, retained austenite, tempered martensite, and very little bainite. Baking the welds at 150°C is equivalent to a low-temperature tempering of the steels. Although the retained austenite amount was not determined quantitatively, it was assumed that it remained unchanged after the baking treatment. Baking the weld samples at 150°C is not expected to cause any changes to the retained austenite because decomposition of retained austenite does not occur until the samples are heated to above 200°C.
The weld fusion zone can be described by atmospheres during the aging process (Ref. 16). No changes in tempered martensite are expected from baking at 150°C either, because the temperature is too low to cause any coarsening of the carbides. Bainite is a very minor constituent either in the weld or the HAZ. This means any property changes in the HAZ and the weld fusion zone can be described by changes that occur in the martensite and ferrite. The changes that can occur in these two constituents are from tempering of the martensite and the bake hardening of the ferrite.

The microstructural changes and the accompanying property changes in tempering of martensite are generally described by grouping the changes into three stages, although there is some degree of overlap of these stages (Ref. 17). The first stage of these includes carbon segregation to dislocations and interstitial sites and clustering and occurs at relatively low temperatures, below 100°C. This carbon segregation is only detected by electrical resistivity measurements and not by any metallurgical techniques (Ref. 16). This step is followed by precipitation of transition carbides that occurs at temperatures between 90° and 200°C (Ref. 16). Therefore, the microstructural changes due to baking are expected to be subtle and minimal. Other changes that occur subsequently at higher tempering temperatures and longer aging times, and are generally considered under subsequent stages, include decomposition of austenite, recovery, and recrystallization. In the present work one needs to be concerned primarily about the carbon atom segregation and clustering and some transition carbide precipitation. The TEM analysis revealed that one significant difference between the as-welded and baked weld samples in the steels is the precipitation of epsilon carbides in martensite in the baked samples.

In the as-welded condition, the dislocation density in ferrite grains and on ferrite grain boundaries was low in the base materials, but much higher in the HAZ and the weld. This is believed to be due to the strains induced by the formation of martensite in the HAZ. In the baked condition, the dislocation density in ferrite was the same as that in the as-welded condition. The martensite region showed epsilon carbide precipitation from the decomposition of twinned martensite.

Baking Mechanism

It is generally agreed that bake hardening in low-carbon ferrite is a strain-aging phenomena that occurs at temperatures higher than those at which natural aging occurs (Refs. 18, 19). It is also generally agreed that bake hardening occurs due to the formation of Cottrell atmospheres during the aging process (Ref. 20). The presence of interstitial atoms, such as carbon, introduces a residual stress field. This stress can be relaxed when the interstitial atoms move to the vicinity of the dislocation cores. This is referred to as Cottrell atmosphere. In Cottrell atmospheres, the interstitial elements pin the dislocations. Any subsequent dislocation movement requires additional force, which leads to an increase in the yield strength of the matrix material. Therefore, from this discussion, it is clear that several conditions must be met for bake hardening to occur. These are the presence of mobile dislocations, the presence of sufficient solute concentration, and the mobility of the solute atoms to migrate to dislocations at the paint baking temperatures (Ref. 20). All of these conditions existed in the dual-phase and TRIP steel baked welds and HAZ.

Meyer et al. studied the bake hardening response of TRIP steel base materials (Ref. 21) and reported that an increase in the yield strength of up to 100 MPa was found after baking the samples. They found a decrease in the carbon content and attributed it to precipitation of carbides. However, no direct evidence of carbide precipitation was provided. The TEM characterization of the bake hardening response of dual-phase and TRIP steels was reported by Timokhina et al. (Ref. 22). They noted that the presence of the upper yield point in the dual-phase steel was evidence of dislocation pinning during bake hardening. They attributed the transition of continuous strain hardening curve in the as-processed condition to discontinuous behavior after the bake hardening treatment to the formation of Cottrell atmospheres that pin dislocations.

In the case of resistance spot welds, both in the weld fusion zone and the HAZ, the microstructure consisted predominantly of martensite, which is a rich source of dislocations. Typical dislocation densities in martensite were estimated to be around 0.3 to 0.9 × 10^{12} cm^{-2} (Ref. 16). Further, compared to typical bake hardenable steels, such as the extra-low-carbon (carbon < 200 ppm) steel, where aging is basically controlled by the available interstitial carbon atoms, both the dual-phase and the TRIP steels have higher carbon present in the steel to provide abundant solute atoms. Therefore, for both the dual-phase and TRIP steel welds, any property changes that result from a baking treatment could be attributed to the formation of Cottrell atmosphere around dislocations due to diffusion of interstitial carbon atoms to the dislocation cores (Refs. 23, 24), and the precipitation of epsilon carbides from the tempering of martensite (Ref. 16).

Property Changes

The average increase in load to failure noted for the TRIP steel welds is 1400 Newtons and for the dual-phase steel welds is 1300 Newtons. The increase in the load to failure for the baked samples for both steels is higher than twice the highest observed standard deviation, which was 480 Newtons. Examination of weld sizes after the tensile tests indicated that the weld sizes were within ±0.1 mm of the aim weld size of 6.3 mm, suggesting that weld size differences did not contribute to increase in the load-bearing ability of the welds. This indicates that strengthening from the baking treatment in welds is small but real. Tests conducted on the base materials in Ref. 17 showed a similar small but consistent increase in the strength of the baked samples.

The dislocation density in ferrite in the HAZ region is much higher in both DP and TRIP steel compared to that in the respective base materials. In the as-welded condition (prior to baking), the highly mobile dislocations lead to lower yield point or strength in the ferrite grains. At the same time, untempered martensite has very high hardness. Such a combination of large areas of soft ferrite and smaller islands of hard martensite can promote easy fracture along the phase boundaries and might be responsible for easier failure when subjected to load.

After baking, Cottrell atmosphere would exert a pinning force against movement of dislocations, thus inducing an upper yielding point when the material is subjected to external stress. In other words, the ferrite would be strengthened to a certain degree. However, the surrounding martensite, when undergoing tempering, would become less strained due to the precipitation of epsilon carbides than fresh martensite. This combination of microstructure, stronger ferrite and less-strained tempered martensite may have aided in improving the load-bearing ability of the welds. Tempering of martensite is expected to improve toughness of both the welds and the HAZs. From a linear elastic fracture mechanics approach, it was shown that the stress intensity at the root of the notch is given by (Ref. 12)

\[ K_{IC} = P/\sqrt{d. t} \]

where P is the load required to cause failure, d is the weld diameter, and t is the thickness of the sheet being welded. In other words, at failure

\[ P_{Failure} = K_{IC}. d. \sqrt{t} \]

This means any increase in toughness at the root of the notch would cause the load required for failure to increase. Therefore, it can be argued that the toughness increase caused by tempering of martensite would also increase the load-bearing ability of the welds. Based on the aforementioned dis-
cussion, it appears in both the dual-phase and TRIP steel welds there are two mecha-
nisms, strain aging of ferrite and tempering of martensite, both of which are believed to
contribute to increased load-bearing ability of the welds. It is believed that TRIP steel,
which showed interfacial fractures, benefited mainly from improvement in toughness
at the root of the notch from baking. Dual-
phase steels, which failed by full button pull-
out fracture, benefitted mainly from yield
strength increase from strain aging of ferrite.

In the case of steels with bulk carbon
levels > 0.2 wt-%, it is believed that car-
bon segregates to lattice defects in the first
stage of tempering and may create a slight
hardening effect (Ref 16). However, with
steels with carbon content < 0.18 wt-%,
there is insufficient carbon to create any
noticeable hardening. This may explain
why no noticeable changes in the hardness
were detected in the welds after the baking
treatment. With epsilon carbide precipita-
tion from martensite, softening generally
occurs in steels, but noticeable softening is
unlikely until tempering temperatures > 200° to 250°C are reached.

It appeared that baking caused subtle
(substructure) changes in martensite and
ferrite and that these subtle changes in martensite and ferrite regions are believed
to have contributed to improved local
yielding behavior in the HAZ. These
changes include 1) the baking introduced
interstitial atmospheres around disloca-
tions and grain boundaries in the ferrite
region, thus it increased the yield strength
of ferrite; and 2) the low-temperature
tempering caused precipitation of transi-
tion carbides ( cementites) in martensite within the
weld and the HAZ. A low-temperature
tempering treatment is believed to result
in a certain amount of toughening within the
microstructures.

Conclusions

The following conclusions can be
drawn based on this study:
1) Postweld baking increased the load-
bearing ability of the welds in the shear-
tension by about 6% compared with that
of the samples in the as-welded condition.
However, no noticeable changes were ob-
served in weld hardness after baking.

2) Baking had no effect on the fracture
mode in shear-tension tests, with the 780
TRIP steel and 780 dual-phase steel ex-
hibiting interfacial separation or button
pull out, respectively, in both unbaked and
baked conditions. However, the maximum
load prior to failure of welds in this study
for both conditions was quite high. This
observation indicates that the occurrence of
interfacial fractures in welds in DP and
TRIP steels does not necessarily indicate
poor weld performance.

3) TEM analysis revealed that postweld
baking resulted in the precipitation of ep-
silon carbides from the decomposition of
twinned martensite in both the DP and the
TRIP steel samples.

4) It is believed that strain aging of fer-
rite and tempering of martensite after bak-
ing resulted in a small increase in the shear-tension strength of DP and TRIP
steels, respectively.

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References

1. Baik, S. C, Kim, S. C, Ji, Y. S., and
Kwon, O. 2000. Effect of alloying elements on
mechanical properties and phase transforma-
tion of TRIP cold rolled steel sheets. SAE
Paper 2000-01-2609, Society of Automatic
Engineers, Warrendale, Pa.

Properties of high strength TRIP steel sheets.
Automotive Body Materials. IBEC.

3. De Meyer, M., Vanderschuren, D., and
De Cooman, B. C. 1999. The influence of Al on
the properties of cold-rolled C-Mn-Si TRIP
XXXVII.

baking on the behavior of resistance spot welds
in a 780 MPa TRIP steel. Sheet Metal Welding
Conference XI, American Welding Society
Detroit Section, Sterling Heights, Mich.

5. Lalam, S. H. 2005. Weldability of ad-
vanced high-strength steels. Great Designs In
Steels Seminar, American Iron and Steel Insti-
tute, Southfield, Mich.

6. Tumuluru, M. 2006. A comparative ex-
mamination of the resistance spot welding be-
behavior of two advanced high-strength steels.
SAE Technical Paper No. 2006-01-1214, SAE
Congress, Detroit, Mich.

7. Regal, J. S., Inazumi, T., Nagataki, T.,
Development of HDGI/HDGGA DP steel fam-
ily. National Steel Corp. 44th MWSP Conference
Proceedings, ISS, Vol. XL.

8. Mahieu, J., Maki, J., Claessens, S., and
De Cooman, B. C. 2001. Hot dip galvanizing of Al
alloyed TRIP steels. 43rd MWSP Conference
Proceedings, ISS, Vol. XXXIX.

technology, and properties of dual-phase sheet
steels. SAE Paper (Series 790008), SAE Con-
gress, Society of Automotive Engineers, War-
rendale, Pa.

Tooling and Methods for Examination
Welding Behavior of Automotive Sheet Met-
terials. American Welding Society, Miami, Fl.


Predicting resistance spot weld failure modes in
shear tension tests. Welding Journal 87(4): 96-s
to 100-s.

13. Khan, M. I., Kuntz, M. L., Biro, E.,
and Zhou, Y. 2008. Microstructure and mechanical
properties of resistance spot weld advanced
high strength steels. Materials Transaction,
49(7): 1629–1637.

Modeling and analysis of bake hardening
behavior in resistance spot welds of high-
strength steels. SAE Technical Paper 982278.

15. Easterling, K. E. Modeling the weld ther-
mal cycle and transformation behavior in the
heat-affected zone. 1993. Mathemtical Modeling
Of Weld Phenomena. Eds. H. Cerjak and K. E.
Easterling, The Institute of Materials.

1043–1054.

17. Krauss, G. 1983. Tempering and struct-
ural change in ferrous martensitic structures.
Phase Transformations in Ferrous Alloys Pro-
ceedings. International conference, Philadel-
phia, Pa. The Metallurgical Soc. of AIME, Ferrous
Metallurgy Committee, Warrendale, Pa, pp.
101–123.

18. Hance, B. M., Link, T. M., and Hoydick,
D. P. 2001. Bake hardenability of multiphase
high-strength sheet steels. 45th MWSP Confer-
ence Proceedings, processing of ultralow car-
on bake hardening steels. Materials Science

modern high-strength steels. ISIJ International,
Vol. 41, pp. 520–532.

2002. Metallurgy and processing of ultralow car-
on bake hardening steels. Materials Science

21. Meyer, M. D., De Wit, K., and
De Cooman, B. 2000. The bake hardening behavior
of electro-galvanized cold rolled C-MnSi and
Al alloyed TRIP steel. SAE Technical Paper
43rd MWSP Conference, No. 12.

22. Timokhina, I. B., Hodgson, P. D., and
Pereloma, E. V. 2007. Transmission electron
microscopy characterization of the bake-hard-
ening behavior of transformation-induced plas-
icity and dual-phase steels. Metallurgical and

23. Waterschoot, T. De, A.K., Vandeputte,
S., and De Cooman, B. C. 2003. Static strain
aging phenomena in cold-rolled dual-phase
781–791.

erty relationship in TRIP steels containing car-
bobide-free bainite. Current Opinions in Solid State

WELDING RESEARCH

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Spot Resistance Welding of a Titanium/Nickel Joint with Filler Metal

The strength of titanium/nickel spot brazed joints produced with the use of a filler metal proved greater than those made without a filler

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ABSTRACT

The shear strength and microstructural characteristics of the spot brazed titanium and nickel base metal was evaluated in this study with and without addition of 71Ag-28Cu-1Mg filler metal at the interfacial region of titanium and nickel. Welding current was varied in a range of 1.0 to 4.0 kA in order to understand the influence of welding current over the final properties of the joints. The strength of the joint was assessed using a shear test mode, and the microstructure was studied using an optical microscope, scanning electron microscope, and energy-dispersive spectroscopy. Results indicated that the strength of Ti/Ag alloy/Ni joint is higher than that of Ti/NI joints when welding current in the range of 2.5 to 4.0 kA was applied. The absence of porosity in the joint and enlargement of the weld nugget significantly improves the bonding strength of the spot brazed joint. This observation is due to dissolution of the 71Ag-28Cu-1Mg filler, which results in diffusion of Ti and Ni into the molten filler, thus the molten filler can effectively wet the Ti and Ni substrate during spot brazing.

Introduction

Titanium and titanium alloys are among the best metals for industrial applications due to their excellent corrosion resistance and high strength-to-weight ratio. Joining of titanium to other metals sometimes is needed due to service requirements. Welding of dissimilar metals is more challenging because of the differences in physical and chemical properties of the base metals, such as poor wettability and different thermal expansion (Ref. 1).

Brazing has been proposed for joining dissimilar metals wherein a filler metal is placed between the base metals and the joining operation is carried out in a furnace at a temperature between the liquids of the filler metal and the solidus of the base metals (Ref. 2). However, in joining of thin metal sheets, such as in electronic and medical devices, spot welding is the most widely used, in which a small weld is formed between two metal workpieces through localized melting due to resistance heating caused by a passage of electric current (Refs. 3, 4). Because of the simplicity of the process, it is easily automated, and once the welding parameters are set, repeatable welds are possible (Ref. 5).

Due to the established interesting features of brazing, which is its ability to join dissimilar metals, and spot welding techniques, which are its ability for automation and forming a spot weld, there is an effort to combine conventional spot welding and brazing principle methods whereby metal bonding is achieved using resistive heating of the filler metal (Ref. 6). Hiratsuka et al. (Ref. 7) have used the term of resistance brazing in their work to show the use of filler sandwiched between the metal workpieces. The implementation of this spot welding technique with a new approach, which refers to brazing using a spot welding machine, will require a better understanding of the issues associated with resistance spot welding of dissimilar metals with the use of a filler metal. This is because resistance weldability of sheet metals is determined by resistivity of the metal components between the copper electrodes, as well as other physical properties such as melting point, latent heat of fusion, and specific heat (Ref. 4).

KEYWORDS

Resistance Weld
Silver Braze Filler Metal
Titanium
Nickel

However, to the authors’ knowledge, literature on this technique such as factors affecting weld quality and the mechanisms involved, are limited. Miyazawa et al. (Ref. 6) have observed several reaction layers at the interface of titanium and nickel-base metals during spot brazing using different filler metals, including Ti-Cu-Ni, Ni-based, Ag-based, and Cu-P filler metals, which influenced the strength of the joints. However, explanation of the growth of weld nugget microstructure and strength in comparison to spot welding of titanium to nickel without filler metals was not discussed in their work. The correlation between spot brazing parameters, microstructure, and joining quality should be defined as well because as in the case of spot welding of BS 1050 aluminum, it was found that a combination of welding current, welding time, and electrode force is required to produce an acceptable weld (Ref. 8).

The joint strength of resistance spot-welded titanium sheets under different atmospheres also gave variation in tensile-shearing strength (Ref. 9). The objective of this investigation is focused on spot brazing of titanium to nickel sheet using 71Ag-28Cu-1Mg filler metal at various welding currents. Microstructure and tensile shear strength of the joined metals were examined and compared to the joints established by spot welding without filler.

Experimental Procedures

Commercial pure titanium and nickel sheets with a thickness of 0.5 mm were selected as a base metal in this study. The metal sheets were cut into 5 × 40-mm pieces. The surfaces of the metal sheets were polished using silicon-carbide paper and cleaned with alcohol prior to welding. Alloy 71Ag-28Cu-1Mg foil with a thickness of 0.1 mm was selected as a filler metal and sandwiched between the overlapping area of the titanium and nickel sheets. A single lap joint of Ti/Ag-alloy/Ni sheets was made using spot welding machine Model SIW-608AD-D0B. A copper alloy electrode with a composition of 98.715 wt-% Cu, 1.175 wt-% Cr, and 0.11 wt-% Al and a 5-mm tip face diameter was
used. The dimensions and configuration of the shear coupon specimen are shown in Fig. 1. The spot brazing was done with a current in a range of 1.0 to 4.0 kA with a current interval of 0.5 kA. Welding voltage was kept at 2 V, electrode force was kept at 3.0 kgf/cm², and a welding time of 50 ms was used. As a comparison, spot welding was also performed on Ti/Ni sheets without addition of filler metal. Hereafter, Ti/Ni and Ti/Ni with filler joints are referred to as spot welded and spot brazed joints, respectively. Five pairs of joints were made for each condition to make the data meaningful.

Joint strength was evaluated using a tensile shear test that was performed using an Instron tensile test machine at a crosshead speed of 1 mm/min. Size of the weld nugget was estimated using a stereo zoom microscope. For microstructure observation, the bonded Ti/Ag-alloy/Ni and Ti/Ni joints were cut close to the cross section of the nugget area before being mounted and polished. Then, the cross-sectioned samples were etched in two solutions. The first solution was a mixture of 5 mL HF, 20 mL HNO₃, and 75 mL glycerol, swabbed from 30 to 60 s on the titanium side, while the second solution was a mixture of 5 mL HCl, 35 mL HNO₃, and 65 mL CH₃COOH, swabbed from 5 to 30 s on the nickel side. The microstructure was observed under an optical microscope and a scanning electron microscope (SEM) equipped with an energy-dispersive spectrometer (EDS).

Results and Discussion

Evaluation of Joining Strength

Test structures for spot welds are usually designed in a way so that the joints are loaded in shear when the parts are exposed to tension or compression loading. Sometimes the welds may be loaded in tension, where the direction of loading is normal to the joint of the plane (Ref. 5). In this work, samples were loaded in the tensile shear direction in order to evaluate the joint quality.

Figure 2 displays the average maximum load of spot welded Ti/Ni joints produced with and without 71Ag-28Cu-1Mg brazing filler metal foil with a welding current range of 1.0 to 4.0 kA. It can be seen that the maximum load of the joints displays a significantly different trend within this current range. In the lower welding current range, i.e., from 1.0 to 1.8 kA, Ti/Ni joints gave higher strength than Ti/Ni joints produced with silver-based foil (maximum load of 0.08 to 0.15 kN and 0.02 to 0.13 kN, respectively. However, in the higher welding current range, i.e., from 2.0 to 4.0 kA, the use of silver-based foil produced stronger Ti/Ni bonds (maximum load of 0.7 to 1.13 kN) compared to spot welding without silver-based foil (maximum load of 0.27 to 0.45 kN).

Welding current is an important variable affecting nugget formation and growth because the power generated for nugget formation is proportional to the square of the welding current. The total heat required to form a weld nugget in conventional spot welding without filler metal includes at least two components
(Ref. 4). The first is to heat the weld metal to its melting point, and the second is to melt the weld metal to form a molten nugget. Miyazawa et al. (Ref. 6) clarified that during spot brazing, the base metal microstructure was coarsened and dissolution phenomenon of the base metal by the molten brazing filler metal took place, which was caused by overheating.

Therefore, the results of the present work suggest that the Ag alloy metal has reduced the contact resistance between the electrode and the metal workpiece, hence reducing the heat/temperature generated at the interface (Ref. 4). As a result, low joint strength was obtained in a lower current level. However, in a higher-current level, the heat generated from the contact resistance at the faying interfaces is sufficient to melt the Ag alloy filler when welding current of at least 2.0 kA was used. Once the Ag alloy filler melts, it penetrates by diffusion through the Ti and Ni base metal during welding. It was seen that for both spot brazed and spot welded workpieces, the weld nugget size increased with the increase in welding current — Fig. 3.

This trend is in accordance with the results obtained by Hasanbasoglu and Kacar (Ref. 1) who investigated the resistance spot weldability of AISI 316L steel to DIN EN 10130-99 steel and concluded that the increase in energy input, which was due to the enhancement of welding current, had increased the weld nugget size. According to Sun et al. (Ref. 10), in the resistance welding, the welding current flowed through the faying surface of two metal sheets compressed by a pair of electrodes. Then the faying surface was locally melted to form the weld nugget by the heat, which resulted from contact electrical resistance. The higher current supplies greater heat and leads to the larger nugget. This is because the time to reach the melting temperature is shorter, and the time spent at or above the melting point is longer.

Result of failure load of the spot brazed joint shows a similar trend with nugget size as the welding current is increased. Increasing the nugget size indirectly widened the load-bearing area in the brazed joint, and thus increased the failure load of the joint (Ref. 11). It has been suggested that there is a direct correlation between joint tensile shear load and nugget diameter in the case of the spot welded magnesium alloy (Ref. 10). Therefore, a similar correlation is observed for spot brazed Ti/Ni joints in the present work. Figure 4 shows the variation of shear stress with welding current. According to Fig. 4, shear stress of the joining increased significantly with the use of brazing filler metal particularly for a high current range, which indirectly indicates an improvement in weldment properties after using brazing filler metal.

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**Microstructure of Weld Nugget**

Figure 5 displays a general view of the spot welded Ti/Ni joint and spot brazed Ti/Ag-alloy/Ni joints observed under an optical microscope.

The cross section of spot welded Ti/Ni joints revealed the presence of porosity within the weld nugget. This observation suggests that the decrease in maximum load of the spot welded Ti/Ni joint is mainly associated with the presence of porosity since the porosity reduces the available bearing area in the joint. This void could be attributed to the incomplete fusion of the Ti and Ni substrates at some points in the interfacial region since the heat generated was not enough to completely melt the metal substrates. Hasanbasoglu and Kacar (Ref. 1) explained that high welding shrinkage strains, which are caused by high thermal expansion, results in an internal discontinuity such as porosity or cavity.

On the other hand, the Ti/Ag-alloy/Ni joint showed no evidence of porosity. A good titanium and nickel wetting behavior of the Ag-Cu-Mg alloy was observed as this filler metal spread over both sides of the titanium- and nickel-based metals. This observation is due to good wettability of the molten 71Ag-28Cu-1Mg alloy on the titanium and base metals (Ref. 12). Minor addition of active ingredient, in this case Mg, improved the wettability of Ag-Cu alloy molten on Ti- and Ni-based metals (Ref. 13). As a result, the use of Ag-alloy brazing filler at the interface of Ti and Ni results in good wetting and a homogeneous diffusion of base metal and hence produced a joint free from porosity. In the case of the Ti/Ni joint, porosity is observed in the weld microstructure. In the case of the Ti/Ni joint with filler, porosity is not evident, instead a silver-rich particle is observed as indicated in the micrograph. Figure 5A shows the porosity inside the welding region of the Ti/Ni joint while no porosity is evident in Fig. 5B. A round shape in Fig. 5B is silver-rich filler metal that does not melt.

The macroscopic sectional view at higher magnification shows in the case of the Ti/Ni joint, grain growth has occurred in the base metal of the nickel side closest to the weld interface — Fig. 6. This re-
gion corresponds to the boundary between the melted and unmelted metal, which experiences the highest temperature. This equiaxed structure changed to a columnar structure in the Ti side, and the direction of growth was observed to be normal to the fusion boundary, which has been reported in several Ti alloys (Ref. 14). This is because the direction of growth of the columnar grain is always along the direction of the steepest temperature gradients in the weld. On the other hand, the sectional view of the Ti/Ag–alloy/Ni joint shows a different solidification pattern and structure. It is seen that the microstructure of Ti- and Ni-based metals does not change significantly and a brazing alloy pool is evident in the weld nugget area.

An EDX analysis was taken across the spot brazed Ti/Ag–alloy/Ni joint at several points as shown in Fig. 7. The brazed joint is mainly comprised of the Ag-rich phase, as marked by point 3, with some evidence of Ti and Ni (Table 1). It means that the dissolution of Ti- and Ni-base metals results in Ti and Ni transport into the molten filler, so the Ag-rich brazed alloyed with Ti/Ni using 71Ag–28Cu–1Mg filler material results in diffusion of Ti and Ni base metals during the spot brazing process, which eliminates porosity in the welded joint as well as enlarges the welding nugget. As a result, the strength of the spot brazed joint has been improved significantly.

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References

Microstructural Characterization of Bonding Interfaces in Aluminum 3003 Blocks Fabricated by Ultrasonic Additive Manufacturing

A look at linking microstructure and linear weld density to the mechanical properties of ultrasonic additive manufacturing builds as well as analyzing their properties with different microscopy and testing methods


ABSTRACT

Ultrasonic additive manufacturing (UAM) is a process by which hybrid and near-net-shaped products can be manufactured from thin metallic tapes. One of the main concerns of UAM is the development of anisotropic mechanical properties. In this work, the microstructures in the bond regions are characterized with optical and electron microscopy. Recrystallization and grain growth across the interface are proposed as a mechanism for the bond formation. The presence of voids or unbonded areas, which reduce the load-bearing cross section and create a stress intensity factor, is attributed to the transfer of the sonotrode texture to the new foil layer. This results in large peaks and valleys that are not filled in during processing. Tensile testing revealed the weld interface strength was 15% of the bulk foil. Shear tests of the weld interfaces showed almost 50% of the bulk shear strength of the material. Finally, optical microscopy of the fracture surfaces from the tensile tests revealed 34% of the interface area was unbonded.

Introduction

Ultrasonic additive manufacturing (UAM) is a solid-state joining process in which thin metallic tapes are ultrasonically welded on top of one another and periodically machined to create a final part. A schematic illustration of the process is shown in Fig. 1. Along with progressive building of a block through seam welding (Fig. 1A), a milling process (Fig. 1B) is used as required to create holes or channels before welding the subsequent layers. The machining operation is also used periodically to produce a flat surface to ensure proper dimensions of the finished build. This process offers many benefits over traditional fusion welding processes such as allowing for complex shapes and designs, having a significantly lower processing temperature, allowing for embedded materials and channels, and offering the capability of joining dissimilar materials that are otherwise difficult or impossible due to UAM being a solid-state process.

The majority of research on UAM is currently focused on optimizing processing parameters (Refs. 1–6) and characterizing the quality and microstructure (Refs. 7–9) of the resulting builds. The four main parameters in UAM are sonotrode amplitude, travel speed, normal force applied, and preheat temperature. Increasing the amplitude, normal force, and preheat temperature, while decreasing the travel speed, generally increases the quality of the bonds. However, above a threshold for each parameter, no further gains are realized (Ref. 5). The threshold effects with respect to sonotrode amplitude and normal force are most likely due to the machine not being capable of delivering enough power to sustain the ultrasonic vibrations at the higher amplitudes and forces. Additional gains in bond quality may be possible with a higher-power system, allowing for higher amplitudes of vibration and forces. For most current UAM machines, optimum parameters are approximately 18–21 μm amplitude, 25–50 mm/s travel speed, preheat of 65–150°C, and normal forces between 800 and 1500 N. Peel tests (Refs. 1, 2, 4, 6), fiber push-out testing (Ref. 3), and microhardness and nanohardness tests (Refs. 2, 9, 10) have been conducted to further the understanding of this additive manufacturing process. These tests are often done along with parameter development to compare the bond quality between different builds. Voids are often present in UAM builds and can be quantified with linear weld density (LWD). The LWD is defined as the length of a particular interface that appears properly bonded divided by the total interface length inspected. The LWD is often used as a test to determine optimum processing parameters (Refs. 1, 2, 4, 5, 11). It is generally agreed that to improve the bond quality of UAM builds, LWD must be kept as high as possible. In most UAM builds, LWD density ranges from 40 to 95%. Ram et al. (Ref. 5) and Johnson (Ref. 7) theorized voids form in UAM builds due to the sonotrode transferring its texture to the workpiece. This results in a situation where the top of each interface is smooth, but the bottom is...
rough. To combat this, it has been demonstrated that milling between layer deposits to provide a smooth-to-smooth interface can eliminate voids, achieving 98% LWD (Ref. 5). However, no tensile, peel, or other quantitative measurement of bond quality was done to verify the bond quality.

Several researchers have made preliminary attempts at mechanical and finite element modeling (FEM) of UAM weldments. Doumanidis and Gao (Ref. 10) used an analytical model combined with experimental data to produce an FEM of UAM useful in simulating different material combinations, embedding of materials, and the production of complex parts. This model also proved useful in determining ideal geometry for the sonotrode and other components. Zhang et al. (Ref. 12) developed a three-dimensional FEM for ultrasonic spot welding that evaluated the ever-changing parameters at each node including normal stress, heat generation, and plastic deformation. Their model used thermal and mechanical conditions to simulate the ultrasonic welding process and led to the theory that ultrasonic bonds are formed due to high levels of localized strain, high temperatures, and plastic deformation along the interface.

Siddiq et al. (Ref. 13) also developed a three-dimensional model focusing on friction and heat generation at the interface. Their simulation determined the effect of friction at the interface to be only useful in removing oxides and contaminates while the plastic deformation of material actually leads to a bond.

Multiple material combinations have been studied, including aluminum, copper, titanium, and nickel (Refs. 11, 13, 14), as well as many different fibers have been successfully embedded including fiber optics, silicon carbides, shape memory alloys, and thermocouples (Refs. 3, 6, 9, 11, 15, 16). The UAM process has been found to easily accommodate these embedded fibers as the ultrasonic energy allows for excellent matrix material flow around the fiber.

In all the above work, a one-to-one correlation of tensile and shear properties with the underlying microstructure has not been documented. Therefore, in this work, the mechanical properties of aluminum builds were measured and observed properties were correlated with the detailed microstructure evaluation using optical microscopy, hardness mapping, and electron microscopy. The results will be compared with published literature on UAM processes as well as data from ultrasonic spot welding. The methodology and data generated in this research are expected to provide a baseline for the development of a very high power UAM (VHP-UAM) instrument (Ref. 17). This instrument will be capable of joining higher-strength alloys including titanium, copper, nickel, shape memory alloys, carbon steels, and low-alloy steels.

### Experimentation

#### Alloys

In this research, a non age-hardenable Al-3003 (Al-1Mn-0.7Fe-0.12Cu wt-%)
alloy was used as both tapes (H18, 150 μm thick, 25.4 mm wide) and substrate (H14, more than 12.7 mm thick). The composition of the materials used meets the standard specification of the alloy (Ref. 18).

**UAM Process Parameters**

The ultrasonic sonotrode was made from Ti-6Al-4V alloy, and the surface was subjected to electrical discharge machining (EDM) to achieve the desired surface texture (Ra = 7 μm). This surface texture is known to provide consistent bond quality (Refs. 5, 7). During the tacking and welding passes, the substrate was preheated with a hot plate to 149°C (300°F) and was maintained at that temperature. The preheat was used to soften the material, which leads to better bonding. However, during processing, the tape and interface temperatures are not necessarily maintained at this preheat temperature due to complex heat transfer across the many weld interfaces, heat generated at the interfaces, and a heat-sinking effect due to the sonotrode.

Sequential joining of tapes to build a small block was achieved through tacking and welding passes. The differences between the tacking and welding passes are related to the magnitude of the process parameters, i.e., normal load, travel speed, and amplitude of ultrasonic vibration. In the current research, the vibration frequency was kept constant at 20 kHz for all passes due to machine and sonotrode design. Table 1 provides an overview of the processing parameters used in the current research. These processing parameters were obtained by extensive trial and error experiments. One method of testing process parameters involves joining of tapes by different process parameters and manually peeling the builds. The best processing parameters are qualitatively selected when the manual peel test fractures the tape, rather than peeling off from the interfacial

**Fig. 4** — Schematic illustration of steps to prepare TEM samples from builds made with UAM. Samples were taken along interfaces at various heights (top, middle, and bottom) of the build. First, optical microscopy samples were prepared to select the regions of interest. In the next step, the sample was transferred to FIB instrument. Then, an interface of interest was selected, and a rectangular region on either side of the interface was coated with platinum. After this step, the focused ion beam machining was made on either side of the coated region. This leads to a thin film sample that contains the bonded interface. In this schematic representation, the n and n + 1 correspond to the successive tapes during the UAM processing.

**Table 2** — Shear Test Results, Base Metal: Al 3003-H18 USS Is 110 MPa

<table>
<thead>
<tr>
<th>Sample</th>
<th>Force (N)</th>
<th>Area (mm²)</th>
<th>USS (MPa)</th>
<th>% of BM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5089</td>
<td>81.6</td>
<td>62.4</td>
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</tr>
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<td>2</td>
<td>4395</td>
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<td>3</td>
<td>8830</td>
<td>215</td>
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<tr>
<td>4</td>
<td>11387</td>
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<td>52.6</td>
<td>47.8</td>
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<tr>
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<td>8.78</td>
<td>47.9</td>
<td>7.9</td>
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<tr>
<td>Standard Deviation</td>
<td>0.167</td>
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</tr>
</tbody>
</table>

**Table 3** — Transverse Tensile Tests, Base Metal: Al 3003-H18 UTS Is 200 MPa

<table>
<thead>
<tr>
<th>Sample</th>
<th>Force (N)</th>
<th>Area (mm²)</th>
<th>UTTS (MPa)</th>
<th>% of BM</th>
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<td>31.9</td>
<td>28.4</td>
<td>14.2</td>
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<tr>
<td>2</td>
<td>979</td>
<td>31.4</td>
<td>31.1</td>
<td>15.6</td>
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<td>3</td>
<td>930</td>
<td>32.4</td>
<td>28.7</td>
<td>14.4</td>
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<td>4</td>
<td>1010</td>
<td>31.4</td>
<td>32.1</td>
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<td>6</td>
<td>601</td>
<td>31.4</td>
<td>19.1</td>
<td>9.6</td>
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<td>7</td>
<td>1080</td>
<td>32.4</td>
<td>33.3</td>
<td>16.7</td>
</tr>
<tr>
<td>Average</td>
<td>28.3</td>
<td>4.81</td>
<td>14.2</td>
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</tr>
<tr>
<td>Standard Deviation</td>
<td>0.170</td>
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<td></td>
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</table>

Fig. 3 — Sample image to demonstrate methodology used for image analyses to derive the linear weld density. A — Original optical microscopy image; B — processed image using ImageJ software.
area. It is important to note that the process parameters used here may not be optimum and are considered as the starting point for this and future research. Details of the peel test instrument and technique have been covered extensively by other researchers (Refs. 19–21).

**Mechanical Property Testing**

Previous mechanical strength studies on UAM samples focused on peel tests (Refs. 1, 2, 4, 6, 22–24). Peel tests, while useful for comparison between parameter sets and other UAM samples, are primarily used for measuring adhesive strength of tape, glue, or other bonded surfaces and do not provide strength values useful for the design of bulk UAM parts. In order to be utilized as an additive manufacturing process, bulk mechanical strengths such as ultimate shear and tensile strengths must be known for design of UAM samples. To date, there has been no reported research on such bulk strength properties. In order to obtain bulk strength properties of the UAM matrix, three types of samples were made: lap shear, transverse tensile, and longitudinal tensile. The geometries of these test specimens are presented — Fig. 2. The shear specimens were built such that the tape interfaces were along the shear plane. Shear tests were conducted using a specialized shear jig and a compressive load with an average displacement rate of 0.28 mm/s.

Initial shear test specimens had a reduced interface area to ensure failure below the 5000-lb machine capability. Initial estimates for strength assumed the shear strength for UAM specimens would be approximately 75% of the bulk material. As testing revealed, the shear strength was much lower than anticipated, and later samples were not prepared with a reduced interface area. The transverse tensile specimens were built such that the

**Table 4 — Longitudinal Tensile Test Results, Base Metal: Al 3003-H18 UTS Is 200 MPa**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Force (N)</th>
<th>Area (mm²)</th>
<th>ULTS (MPa)</th>
<th>% of BM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2630</td>
<td>11.71</td>
<td>225</td>
<td>112.5</td>
</tr>
<tr>
<td>2</td>
<td>2900</td>
<td>12.21</td>
<td>238</td>
<td>119.0</td>
</tr>
<tr>
<td>3</td>
<td>2880</td>
<td>12.03</td>
<td>240</td>
<td>120.0</td>
</tr>
<tr>
<td>4</td>
<td>2870</td>
<td>12.13</td>
<td>237</td>
<td>118.5</td>
</tr>
<tr>
<td>5</td>
<td>2790</td>
<td>11.95</td>
<td>233</td>
<td>116.5</td>
</tr>
<tr>
<td>Average</td>
<td>234</td>
<td>117.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>5.89</td>
<td>2.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stdev/Avg</td>
<td>0.025</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
tape interfaces were perpendicular to the applied axial force. Transverse tensile tests were conducted using specialized specimen shoulder grips with an average displacement rate of 0.32 mm/s. Longitudinal tensile specimens were built with tape interfaces parallel to the applied axial force and were tested using pinned grips with an average displacement rate of 0.52 mm/s.

For all tests, samples were placed in a universal tension/compression testing frame and were stressed until failure. The applied force was recorded using a tension/compression load cell and frame actuator displacement with an integrated linear variable differential transformer (LVDT). Maximum loads were used to obtain ultimate stresses, and the shape of the force-displacement plots was used to help characterize specimen failures. Because the integrated LVDT measures the testing frame actuator displacement, all displacement data includes displacement generated within the load train as well as the specimen. For this reason, the shape of the force-displacement plots can only be used to determine if a given sample failed in a brittle or ductile mode through qualitative analysis. However, this cannot be used to calculate specimen strain or related properties such as the elastic modulus. After the mechanical testing, the fracture surfaces of the shear and transverse tensile samples were examined with optical and scanning electron microscopy (SEM).

**Optical Microscopy and Hardness Mapping**

Optical metallographic samples were prepared using standard metallographic techniques. The samples were prepared from cross sections perpendicular to the travel direction. Five optical images at 10x magnification were taken from different locations within the build. Each image corresponded to 1111 by 833 μm, containing five interfaces. These microscopy images were analyzed with the public domain ImageJ software program (Ref. 25). With linear intercept analyses, the LWD was measured as a function of distance in a direction perpendicular to the metallic tape layers. Grayscale image threshold values (0 to 60) were kept constant to delineate the void areas in all these images. A typical optical image before and after threshold processing demonstrates the effectiveness of delineating the voids between layers — Fig. 3A, B.

For the microhardness testing, a Leco AMH-43 machine was used to create a 200 x 20 map of hardness indents with a diamond indenter. The measurements were made with 25-g load and a 13-s dwell time, and spacing between the hardness indents was 150 μm in both directions. The coordinates of the indents were designed to sample the solid matrix regions away from interfaces. Hardness measurements were made on tapes that were not ultrasonically consolidated in the same orientation, as a reference point.

**Analytical Electron Microscopy**

In order to examine the grain structure and morphology in specific locations (bottom, middle, and top regions of the build) through transmission electron microscopy (TEM), the samples were prepared using a FEI Helios dual-beam focused ion beam (FIB) microscope. The samples were prepared from cross sections perpendicular to the travel direction along interfaces with apparent good bonding. The FIB

<table>
<thead>
<tr>
<th>Table 5 — Linear Weld Density (%) from Optical Micrographs Taken from Random Locations within the Build</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image Number</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>Overall</td>
</tr>
</tbody>
</table>

Fig. 6 — Measured load vs. displacement curves. A — Shear tests with symmetric and reduced cross sections; B — transverse tensile tests; C — longitudinal tensile tests.
contains both an electron beam as well as an ion beam that can be used for imaging. The electron beam is a standard secondary electron beam, which can be used to image topological differences but does not reveal grain structure in unetched aluminum alloys. The ion beam was used to image the grain structure of the material with contrast differences arising from gallium ion channeling contrast. To create TEM foils, platinum is deposited over the region of interest to protect the foil surface from Ga+ implantation during milling. Trenches are then milled on both sides of the platinum to create the foil. The sample is then bonded to an omniprobe needle also using platinum. The sides of the foil are then milled to create a free-standing foil. Once the sample is cut free, it is lifted out using the omniprobe needle and welded to a copper grid using platinum. Once the sample is welded to the grid, it is thinned using ion milling and a series of various apertures at 30 kV. The steps used in making the samples are schematically illustrated in Fig. 4. Finally, the samples were then examined using a FEI Tecnai F20 operated in STEM mode.

Results and Discussions

Mechanical Properties

The original mechanical properties of Al 3003-H18 alloys are as follows: The ultimate tensile strength (UTS) is 200 MPa, the yield strength (YS) is 186 MPa, and the ultimate shear strength (USS) is 110 MPa (Ref. 18). The mechanical property data from this research program are summarized in Tables 2–4. All shear tests resulted in a linear force-displacement relationship, indicating samples failed in a macro-level brittle fracture mode. As shown in Table 2, an average USS of 52.7 MPa with a standard deviation of 8.78 MPa was found. The average USS was approximately 48% of that of the solid base material. The results from the transverse tensile tests are shown in Table 3. The average ultimate transverse tensile strength (UTTS) was 28 MPa, approximately 15% of the tensile strength of solid base material. Standard deviation for UTTS was 4.57 MPa.

To understand the reduced strength of the transverse tensile test samples, the fracture surfaces were characterized using optical and scanning electron microscopy. The fracture surfaces from the samples from 1 to 5, as well as samples 7 and 8, share a similar fracture surface — Fig. 5. These images indicate that the interface regions have many small speckled-like features dispersed throughout the bond area. This feature is due to small areas of bonded material (marked as I in Fig. 5A) mixed with small areas of unaffected material (marked as III in Fig. 5B). In order to make sure the Region I (Fig. 5B) is a true bond, the fracture surfaces from either sides of the fracture were characterized with scanning electron microscopy (Fig. 5C, D). Scanning electron microscopy showed that the fracture surfaces do show localized ductile failure with typical microvoid coalescence features. This is irrespective of the fact that the load-displacement curves do not show appreciable macro level ductility. These observations proved that the ultrasonic additive manufacturing did not reduce the inherent ductility of the material; however, on a macro scale, the material behaved in a brittle fashion due to the voids. The lack of a yield point and hardening region is related to premature brittle fracture caused by the voids.

Transverse tensile samples behaved similar to the shear samples, as indicated by the linear force-displacement plots — Fig. 6A, B. From Fig. 6B, sample 6 is considered to be an outlier, as seen by its much lower failure force when compared to the other samples. Upon examination, the fracture surface of the sample 6 showed interesting features that were different from the other samples inspected — Fig. 7A. Optical microscopy showed trenches and ridges, which are typical of surfaces created by a milling operation (Ref. 7). Furthermore, scanning electron microscopy showed that the bonds have formed along these ridges and have failed again by ductile mode — Fig. 7B, C. Cursory evaluation of the above fracture morphology may be puzzling; however, this phenomenon may be explained. During the UAM process, at frequent intervals a milling operation is performed to achieve a flat surface to ensure dimensional accuracy of the finished part. In sample 6, the failure occurred at one such milled interface. The fracture surface showed that the area fraction of the bonded region was small compared to unbonded regions, likely the rea-
son for the premature failure of this sample. All of the samples tested had this flat pass within them; however, only sample 6 failed in this manner. Because it is not known why the other samples did not fail at this location, it is believed that sample 6 does not give a true representation of UAM bond tensile strength and is also excluded in statistical analysis. The sensitivity of surface roughness on the bond quality has been addressed by previous researchers (Refs. 7, 22) by relating the surface roughness of the sonotrode to changes in linear weld density.

Unlike the other UAM samples, the longitudinal tensile samples (Table 4) exhibited a substantial plastic yielding region after the linear elastic region — Fig. 6C. This is more typical of aluminum alloys and indicates that failure occurred in a ductile mode. All tested samples exhibited a higher than expected tensile strength. The average ultimate longitudinal tensile strength (ULTS) was 234 MPa, 17% more than the original Al 3003-H18 tape based on published properties (Ref. 18). This is a departure from both the transverse tensile samples and shear samples previously tested in which the failure stresses were significantly lower than the Al 3003-H18 tape based on published properties (Ref. 18). In this orientation, no drop in tensile strength was expected as the load was transmitted along the solid tapes as opposed to across the interfaces between them. However, the increase in strength above the base material was not expected and further explanation of this phenomenon is required.

**Microstructure and Mechanical Heterogeneity**

To rationalize the reduction in mechanical properties in the transverse loading condition, the LWD of the builds in different regions were analyzed. A typical data set of linear void density (inverse of LWD) is shown in Fig. 8. The image analyses show the LWD can vary from 35 to 99%, depending on the interface. The average LWD of all the images analyzed was found to be 65.2 ± 15.3%, (Table 5). Image analyses of optical micrographs of the fracture surface of the transverse tensile samples (Fig. 5) yielded 60 ± 2% bonded areas. In Fig. 5D, it is clear the voided regions are random in nature. In stereological terms, randomly placed line segments in cross-sectional images are proportional to an object’s area in a 2-D plane (Ref. 26). However, in the current study, only one cross-sectional plane was used. This prevents the conclusion that LWD is directly related to area density of properly bonded material in UAM builds, despite the averages being comparable. With additional angular cross sections and more samples, it may be possible to confirm a possible one-to-one relationship. Regions with lower amounts of bonded area within the build are expected to reduce the transverse and shear strength significantly. This hypothesis is consistent with the conclusions made by previous researchers that linear weld density is a good measure of UAM bond quality.

The mechanical properties measured along longitudinal sections showed a 17% increase in ULTS compared to that of the original Al 3003-H18 tape materials. In order to rationalize this increase in strength, hardness mapping was performed on the UAM builds. The map shows a soft substrate and UAM build regions with large variations in hardness — Fig. 9A. The hardness data were analyzed in terms of frequency distribution — Fig. 9B. This graph also shows the hardness

![Fig. 8](image_url) — Plot of linear void density (LVD) vs. five interfaces; B — the corresponding optical image number 5. The LVD point for each interface was taken as the high point and is shown. Linear void density is the inverse of linear weld density.

![Fig. 9](image_url) — Microhardness plot of a UAM build. A — The map was 200 indents tall by 20 indents wide, with the softer substrate at the bottom. No gradient in hardness (either from bottom to top of build or left to right of build) was observed. This indicates later passes have minimal effects on the hardness of previously deposited layers; B — histogram showing bimodal hardness distribution with the UAM build foils significantly harder than the substrate. The hardness of unconsolidated foils is also overlaid on same plot and is below the peak hardness of the UAM build; C — optical image showing a high hardness foil indent on left (90 HV) next to a weaker interface indent on the right (30 HV). Interface areas with voids or defects caused by insufficient material flow to fill in grooves cut by sonotrode during previous pass had lower hardness.
distribution from the original Al 3003-H18 foils, which had an average hardness of 64.5±2.7 HV. The UAM build had an average hardness of 73.7±1.9 HV. The data show that the UAM builds are indeed harder than the stock foils and provide a qualitative explanation of the increase in ULTS. Careful analyses of hardness indents in certain regions also showed interesting features — Fig. 9C. In one region, a small indent showing high hardness was right next to a large indent showing low hardness. This low hardness was associated with a large planar defect (marked by arrows). Although the weakened regions may be explained with the presence of unbonded areas, it is necessary to evaluate the hardened regions through detailed microstructure characterization.

Transmission electron microscope samples from the interfaces from the bottom (near substrate), middle, and top regions of the build were extracted through FIB machining. The electron microscopy images are presented — Fig. 10A–E. The microstructure of the original foil is also provided for comparison — Fig. 10F. Interestingly, the microscopy images from the bottom (Fig. 10A) and middle (Fig. 10B) regions failed to show any sharp interface region indicating the formation of a metallurgical solid-state bonding. The grains were equiaxed in nature, quite different from that of elongated grains of the original Al 3003-H18 tapes — Fig. 10F. This suggests that the bond formation may be associated with recrystallization. In addition to the equiaxed grains, fine Al-Mn-Fe-based intermetallics were observed in the samples along the grain boundaries and within the matrix grains. These intermetallics are found in the original Al 3003-H18 tapes and do not appear to be affected by the UAM process. The interface microstructure (Fig. 10C) from the top region showed interesting features. The original interface location can be inferred from the sudden change in the grain structure. The microstructure in the \((n + 1)^{th}\) tape shows the original pancake structure, which transitions sharply to a coarse and recrystallized grain structure close to the original interface location. The microstructure from the \(n^{th}\) layer does not show any pancake structure, rather more recrystallized structure. Moreover, a region of grain boundary decohesion was also observed. This grain boundary decohesion was also confirmed with high-magnification analyses — Fig. 10D. A survey of many samples from different regions also showed the interface regions contained fine recrystallized grains (< 500

Fig. 10 — Six TEM images. A — Bright field TEM image taken from an interface location with apparent good bonding. The interface cannot be determined easily, indicating potential recrystallization across the interface. Small, white Al-Mn-Fe intermetallics can be seen here; B — another interface location again showing the difficulty in discerning the bond line; C — a third interface location where the bond line can be determined, as pointed out by the red arrows. The blue arrow points to a small void that appears to have migrated from the interface into the bulk of the material; D — high-magnification bright field image of the void in C; E — dark field image showing the high levels of dislocations within the grains and the Al-Mn-Fe intermetallic particles; F — bright field image of the original foil before consolidation. The as-rolled structure is pancake-like grains with some dislocations present. Dislocation content significantly lower than that observed after UAM processing.
Fig. 11 — Schematic representation of the UAM process highlighting the various stages. A — Beginning of new layer, top of previous layer textured by sonotrode during previous layer bonding; B — New layer, 2, placed by feeding mechanism in front of sonotrode; C — sonotrode tacks the new layer down, generating frictional heat and forming a weak bond; D — new layer tacked down, many residual voids present; E — sonotrode passes again for welding pass, deforming the top surface as it passes; F — layer 2 attached, some voids are still present between layers 1 and 2; G — third layer ready to be added. Enlargement of bond interface showing the three regions. Region I is well-bonded material, Region II is valleys carved by sonotrode, and Region III is untouched material.

Discussion on Process-Structure-Property Correlations

In order to understand the interface microstructure, it is important to review the steps involved in the UAM process, shown schematically in Fig. 11. In Fig. 11A, a first layer has been bonded to the substrate, with the top of this layer left in a rough condition after the sonotrode rolled over it. When the next layer is applied, the bottom of the new layer is relatively flat, creating an interface between a smooth surface and a rough surface — Fig. 11B. When the sonotrode comes directly on top of the interface during the tacking pass, the relative motion between the two layers creates frictional and deformational heating and partially collapses asperities — Fig. 11C. This results in a weak bond between the layers, with many voids as shown in Fig. 11D. During the welding pass, more ultrasonic energy (higher forces and amplitude of vibration) is used to finish the bond — Fig. 11E. Some residual voids remain, as shown in Fig. 11F.

The final microstructure at the interface can be summarized to consist of three regions as shown in Fig. 11G. During the welding of the previous layer, the top surface of each foil interacts with the sonotrode and becomes rough. This rough surface becomes the bottom of the following interface. Where peaks occurred along the rough surface, contact was made with the new foil and a bond resulted (Region I). This region constitutes recrystallized microstructure (500 nm to 2 μm) across the interface and has good metallurgical bonding. It is believed when these peaks are brought into contact with the new foil layer sufficient strain energy, temperature, and forces exist to force dynamic recrystallization. However, where valleys occurred due to the sonotrode texture, Region II, they were often too deep to make contact with the next layer being added. This resulted in voids along the interfaces and created the Region III material on the foil directly above it. Region III is the unaffected original foil surface that has not been touched by either the sonotrode or the foil layer beneath it. Region III was only found on the top surface of the interface. Region II material was directly opposite and the cause of Region III material. In this study, focus was given to understand the mechanism of the grain structure evolution in Region I. Based on the microstructure from Fig. 10A–C and E, we can conclude that the original pancake grain structure was modified to form sub grains with sizes ranging from 500 nm to 2 μm with different levels of dislocation density. To understand this reduction in grain size, we assume this process is similar to that of hot working of aluminum alloys. The subgrain size (d_{sub} in μm) during hot working can be related to Zener-Hollomon (Z_H) parameter and peak temperature (T_p) achieved during hot working (Refs. 27, 28).

\[ d_{sub} = \left( -0.60 + 0.08 \log(Z_H) \right)^{-1} \]  

Equation 1 has been used to estimate the grain size in both friction and friction stir welding. The Zener and Hollomon (Z_H) parameter has been estimated for
aluminum alloys as a function of strain rate (\(\dot{\varepsilon}\) in \(s^{-1}\)) and peak temperature \(T_P\) (Ref. 29).

\[
Z_h = \dot{\varepsilon} \times \exp\left(\frac{18,772}{T_P}\right) \tag{2}
\]

In order to understand the subgrain structure in UAM process, Equation 2 was used. The strain rate during ultrasonic adhesive manufacturing is calculated using the following approximation. The total displacement due to the plastic deformation, a thin slab of material under the horn, can be taken as the horn amplitude, i.e., \((\Delta d = 26 \times 10^{-6} \text{ m})\). This assumes there is no slippage of the interface material. The asperity height is estimated as the peak-to-peak height of the tape surface. This surface is assumed to be a negative image of the sonotrode texture, which has a value of \(7 \times 10^{-6} \text{ m}\), as reported by Johnson (Ref. 7). Thus, the peak-to-peak height of the average asperity is \(14 \times 10^{-6} \text{ m}\). Furthermore, the height of the asperities is assumed to have negligible change with respect to time. With these assumptions, displacement of the bonded regions with respect to time can be given by the expression:

\[
d(t) = 26 \times 10^{-6} \times \sin(2\pi \times 20,000 \times t) \tag{3}
\]

Asperity velocity is calculated as the derivative of displacement with respect to time:

\[
\dot{d}(t) = v(t) = 3.3 \times \cos(2\pi \times 20,000 \times t) \tag{4}
\]

The shear strain of an asperity is given by the equation:

\[
\gamma = \tan^{-1}\left(\frac{\dot{d}(t)}{h}\right) \tag{5}
\]

Shear strain rate is then found by taking the derivative of strain with respect to time as follows:

\[
\dot{\gamma}(t) = \left(\frac{1}{\left(\frac{d(t)}{h}\right)^2 + 1}\right) \times \frac{\dot{d}(t)}{h} + \frac{\dot{d}(t)}{h} \times \frac{\dot{v}(t)}{h} \tag{6}
\]

Over one ultrasonic cycle, an asperity will have a strain rate varying between \(\pm 2.3 \times 10^6 \text{ rad/s}\) with an RMS value of \(\pm 1.1 \times 10^6 \text{ rad/s}\). Because we do not know the peak temperatures experienced by interface regions, the subgrain sizes were evaluated as a function of peak temperature and strain rate. This is shown as a form of contour plot — Fig. 12. The calculated micro strain rate from Equation 6 results in a peak temperature of around 300 K for the 500-nm grains and a peak temperature of 900 K for the 2-\(\mu\)m grains. This range of temperatures is larger than expected, but this may have been caused by the approximations in Equations 1 to 6. In Equation 6, perfect transfer of strain was assumed, no slipping between the sonotrode and the foil was accounted for. Account for slipping, the resulting strain, and therefore peak temperature required to achieve a certain grain size, would have decreased. Meanwhile, Equations 1 and 2 were developed for simple monotonous hot working conditions and not reversible strains that are experienced during UAM. Gounder et al. (Ref. 30) estimated a local strain rate of \(1 \times 10^6 \text{ rad/s}\) at a temperature of 513 K based on vacancy calculations and the diffusion profile observed in aluminum-zinc ultrasonic welds. This work was based on finding the vacancy concentration required to reduce the melting temperature so the observed small melt region was possible at ultrasonic welding temperatures. Their result is within the range of grain size, temperatures, and strain rates studied here. Conversely, macro strain rates were studied by Gao and Doumanidis (Ref. 31) by placing a strain gauge near, but not directly beneath, the welding sonotrode. They found maximum strains of \(90 \times 10^{-6}\) over 0.5 s or \(1.8 \times 10^{-4} \text{ s}^{-1}\). This low strain rate is expected as Gao and Doumanidis measured macro strains with a strain gauge of a much larger size scale than the asperities used in Equation 6.

Recently, Johnson has proposed that the materials under reversible straining conditions may exhibit an Ultrasonic Bausching effect (Ref. 7). However, the interaction of these effects with heating and subgrain formation is not clear. In addition, the estimated strain rates have to be validated based on detailed finite element deformation models (Ref. 12), which considers the spatial variations as well as dynamic strain hardening or softening. The localized temperature along interfaces may be affected by the friction and rapid deformation conditions. In the current UAM process, the substrate temperature is maintained at 149°C (422 K). This heat will diffuse from the substrate to the entire build. As a result, with the progress of UAM builds, the previously welded interfaces will be subjected to an isothermal hold close to this temperature throughout the processing of the build. This isothermal hold is also expected to induce some of the recrystallization and grain growth observed. This suggests the need for measuring the spatial and temporal variations of the temperature during the UAM process. This will be the focus of the future work (Ref. 32). The next step is to provide some directions to rationalize the measured mechanical properties. From the above discussions, it is apparent that all UAM samples will have large voids along the interfaces as well as localized hard and soft regions. The voids can be treated as embedded cracks, which cause stress concentrations that resulted in brittle fracture of the shear and transverse tensile specimens. The loading of the transverse tensile samples results in a mode I fracture, while the shear sample loading induces mode II fracture. For a given crack and load magnitude, mode I fracture loading typically exhibits the largest stress intensity factor (SIF) followed by mode II fracture (Ref. 33). Because loading is parallel to the embedded cracks in the longitudinal tensile samples, there is no SIF and the strength in this orientation was not reduced. This fracture mechanics perspective further explains why the shear and transverse tensile samples have lower than normal strengths and brittle fracture characteristics, while the longitudinal samples were not weakened by the presence of voids and instead failed with ductile characteristics. Again, the above discussion is simplistic, does not provide a predictive capability, and does not account for all transients that have been observed, such as the variations in tensile testing shown — Fig. 6. Further work is necessary to develop detailed computational models that incorporate the spatial variation of microstructure and voids and constitutive response of the bulk and interface location. To facilitate the development of constitutive properties of the interface locations, the grain size distribution along the interface has to be characterized close to the voids and away from the voids using orientation imaging microscopy. This grain orientation and size distribution will allow us to develop multiscale models similar to the ones being developed by Ghosh (Ref. 34).

Finally, in order to overcome the deep channels carved by the sonotrode, a very high power UAM system is being developed by EWI (Ref. 17). It is believed that higher ultrasonic power input, higher amplitudes, and normal forces will increase the plastic flow at the interfaces. This should enable greater LWD, reducing the inherent stress concentrations and improving the tensile and shear strength of UAM builds. Higher plastic flows should also improve the metallurgical bonds by ensuring all of the oxides are removed from the interface.
Conclusions

The present study focused on linking microstructure and LWD to mechanical properties of ultrasonic additive manufacturing builds. Using TEM, SEM, and optical microscopy along with microhardness and tensile and shear testing, the microscopic and macroscopic properties of UAM builds were analyzed. The following was found:

1. The average shear strength of the tested UAM samples was approximately 48% of the expected 110 MPa ultimate shear strength of Al 3003-H18. The average transverse tensile strength was approximately 14% of the expected 200 MPa tensile strength of Al 3003-H18. Transverse tensile and shear testing results are indicative of bond quality alone; failure occurs before microstructure becomes significant.

2. Without optimized parameters, UAM weldments result in voids scattered throughout all interfaces. This ultimately causes the samples to fail in a low ductility manner with low strength values.

3. Image analysis of cross-sectioned samples found an average linear weld density of 67.4 ± 16.1%. Image analysis of transverse tensile fracture surfaces found an average area weld density of 66 ± 2%. A direct comparison between LWD and area weld density was not possible based on the sample size.

4. The average longitudinal tensile strength was approximately 117% of the expected tensile strength of Al 3003-H18. This indicates the foils were strengthened during processing and was confirmed by microhardness testing. Microhardness testing found the average hardness of the UAM foils increased almost 15%, from an expected peak temperature range for the UAM process of 300 to 900 K was estimated peak temperature range for the UAM process of 300 to 900 K was

5. A hypothesis relating grain refinement to strain and temperature using the Zener-Hollomon parameter was developed. Microstrain rates were estimated based on operating conditions to be around 1 × 10^3 s⁻¹. From this and an observed grain size of 500 nm to 2 μm, an estimated peak temperature range for the UAM process of 300 to 900 K was calculated.

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