

# Insights



## Use of Duplex Stainless Steels for Non-backing Gas Pipeline Applications

Nate Ames | Energy & Chemical Market Leader

There is interest within the pipeline industry to integrate duplex stainless steel (DSS) into newly constructed pipelines as an alternative to carbon steel. DSS would dramatically decrease the tonnage of material used in the pipelines due to increased material strength, and could reduce or eliminate service related pitting corrosion and cavitation induced corrosion.

With the recent relative reductions in DSS base material cost along with development of an alternative root bead welding procedure using shielded metal arc welding (SMAW), gas metal arc welding (GMAW), or flux-cored arc welding (FCAW) that do not require backing gas, the use of DSS is becoming more economically feasible.

With this in mind, ConocoPhillips contracted EWI to evaluate the feasibility of producing production girth welds on DSS pipelines without the use of backing gas. The work was completed under the assumption that the final application would be Arctic North

Slope environments and would be required to meet a maximum allowable hardness of 310 Hv for both the weld metal and HAZ, an ASTM G48 accelerated corrosion test, and Charpy impact toughness test requirements of 50/40 ft-lb at -50° F (50 ft-lb average with a minimum of 40 ft-lb).

The work initially commenced on 8-in. by 0.25-in. wall 2205 DSS pipe. Following optimization and acceptance of the 8-in diameter pipe weld procedure, the work was expanded to include 3-, 4- and 6-in. by 0.25-in. wall 2205 DSS pipes. The girth welds of the four pipe diameters were evaluated and accepted in accordance to the ConocoPhillips specification and ASME B31.3. The weld procedures were then transferred to the field, where a production welding team was qualified to produce DSS welds without the use of backing gas.

As development continues, breakthroughs such as this DSS welding project lead to enhanced mechanical integrity solutions for

the Arctic North Slope. Development of such projects leads to overall reduced risk and a higher quality product for environmentally sensitive areas such as the numerous tundra lakes and river channel crossings characteristic of the Arctic North Slope. Furthermore, below-grade crossings that cannot be confidently inspected with existing NDE techniques are also excellent candidate locations for employing DSS in the future. Expansion projects within existing fields and development areas such as the expansion into the National Petroleum Reserve-Alaska (NPR-A) may also benefit from the reduced life-cycle costs gained through use of this welding technology development. It is anticipated that this work will further decrease the overall fabrication and construction cost of joining DSS materials and therefore make the materials more attractive to new projects throughout Arctic North Slope fields.

For more information or to discuss a potential application, please contact Nate Ames at 614.688.5135 or [nate\\_ames@ewi.org](mailto:nate_ames@ewi.org).

# The President's Corner

As EWI's new President and Chief Executive Officer, I am looking forward to starting the next phase of business growth of one of Ohio's most successful technology ventures.

The past two decades have been an exciting period for EWI. Under the leadership of my predecessors Karl Graff, Ted Ford and Don Caudy, EWI has grown from a handful of engineers in a renovated warehouse into a world class engineering organization in a state-of-the-art facility serving a diverse global membership.

Over the past five years, the organization has grown steadily and established a sound financial footing. More importantly, our ability to serve our members and other stakeholders has improved continuously. We recently hosted over 200 companies at a technology workshop in Columbus, where we rolled out a number of new joining technologies developed under our internally directed Cooperative Research Program. Earlier in the year, we developed and deployed welding procedures for producing over 400,000 low-cost, high quality aluminum welded joints for critical applications at USEC's new gas centrifuge enrichment plant. We also conducted a customer site assessment that led to cost savings and job retention for one of our member's key customers. You can read more about this in the 'Success Story' section of this newsletter.

As a materials scientist, I have a special affinity for the work that is done at EWI. Great products and structures serve no one if they cannot be manufactured reliably and economically from materials with the desired properties. Materials joining is a critical step in the



Henry J. Cialone

manufacturing process, and EWI is here to serve its customers by advancing and applying technologies that improve cost, performance and reliability through this step. This issue of Insights provides some specific examples of technological advancements from defense and industrial applications, including an introduction to nitinol joining processes.

Looking ahead, I am excited about the opportunity to present new product and service offerings to our customers. We have established a special team to develop concepts that we will first test internally, and then with our members. I invite all of our members to send me your thoughts as to what products and services you would value; please e-mail me directly at [henry\\_cialone@ewi.org](mailto:henry_cialone@ewi.org).

Finally, I want to give special thanks to our customers and employees. As members, your partnership with and trust in EWI allows us to collaboratively solve your complex materials joining challenges. And the technical excellence and professional dedication of the EWI Associates have made it possible to deliver the high quality of service that you expect from EWI.



## EWI Hosts Magnetic Pulse Technology Workshop

EWI will be hosting a one-day workshop highlighting the latest principles in magnetic pulse technologies. It will take place on September 15, 2005 at EWI's headquarters at 1250 Arthur E. Adams Drive, Columbus, Ohio.

During this workshop, a wide range of magnetic pulse technologies will be covered. A tour of EWI's facilities will be conducted whereby EWI engineers will demonstrate the latest magnetic pulse joining technologies. This workshop is designed for managers and engineers in various industries including automotive, light manufacturing, aerospace, energy, heavy manufacturing, electronics and medical devices.

The following topics will be presented:

- fundamental and material behavior of high rate processing
- basics and physics of electromagnetics
- magnetic pulse applications (forming, welding, cutting, etc.)
- coil and tooling designs and fabrications
- modeling approaches for magnetic pulse technology

The workshop cost is \$150.00 for EWI members and \$225.00 for non-members. If you are interested in attending, please fill out the registration form by September 2, 2005, as seating is limited. More information is available on our website at <http://www.ewi.org/events/seminars.asp#WORK>.

We hope you will take advantage of this opportunity and join us in Columbus in September.

Insights is produced four times per year. Please direct general questions and comments to Lisa McClintock, Marketing Communications Manager, at 614.688.5130 ([lisa\\_mcclintock@ewi.org](mailto:lisa_mcclintock@ewi.org)). Questions relating to an article may also be directed to the contact listed in the article.

### EWI

1250 Arthur E. Adams Drive  
Columbus, OH 43221-3585  
614.688.5000 FAX 614.688.5001  
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## Please join EWI in congratulating several employees on their selection by the AWS Committee to receive the following awards:

Bill Bruce received the A.F. Davis Silver Medal Award. This is awarded to the authors of papers published in the Welding Journal during the previous calendar year that represent the best contributions to the progress of welding in the categories of (1) machine design, (2) maintenance and surfacing and (3) structural design. Bill won in the category of “maintenance and surfacing” for “Maintenance Welding on the Trans-Alaska Pipeline.”

Harvey Castner was honored with three awards: AWS Fellow, National Meritorious Award and the Health and Safety Award.

The honorary title of AWS Fellow was established in 1990 to recognize members who have made distinguished contributions and promoted and sustained professionalism in the field of welding science and technology. Election as Fellow of the Society is based on the reputation and outstanding accomplishment of the individual. Such accomplishments will advance the science, technology and application of welding in specific areas such as research and development, education, manufacturing, design and other areas the Society may determine, as evidenced by: sustained service and performance in the advancement of welding science and technology; publication of papers, articles and books which enhance the knowledge of welding; and innovative development of welding technology. Contact Wendy Reeve at AWS ([wreeve@aws.org](mailto:wreeve@aws.org)) for the specific list of accomplishments that led to Harvey's election.

The National Meritorious Award is given in recognition of good counsel, loyalty and devotion to the affairs of the AWS; assistance in promoting cordial relations with industry and other organizations; and for the contribution of time and effort on behalf of the Society.

The Health and Safety Award recognizes individuals for promoting welding safety and health through research, educational activities, development of safe practices, or dissemination of information through publications or other means, thereby fostering public safety awareness and welfare.

Nancy Porter was awarded the honorary title of AWS Counselor. Created in 1999, the honorary title of AWS Counselor was created to recognize individual members for outstanding organizational leadership that has helped enhance the image and impact of the welding industry. Election as a Counselor of the Society is demon-



*Bill Bruce*



*Harvey Castner*



*Nancy Porter*



*Wei Zhang*

strated as evidenced by: 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 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 evidence by support of participation of its employees in industry activities. Contact Wendy Reeve at AWS ([wreeve@aws.org](mailto:wreeve@aws.org)) for the specific list of accomplishments that led to Nancy's election.

Wei Zhang was recognized with the William Spraragen Memorial Award. In honor of William Spraragen, a founding member of AWS and the first Editor of the Welding Journal, the award is given for the best paper published in the Research Supplement of the Welding Journal during the previous calendar year. Zhang was co-author of the winning paper entitled “Direct Observations of Austenite, Bainite, and Martensite Formation during Arc Welding of 1045 Steel Using Time-Resolved X-Ray Diffraction.”

## Nitinol Joining: A Process to Address the Difficulty in Joining Nitinol to Other Metals

The super-elastic and shape memory properties of nitinol make this unique material attractive for several applications. Super-elasticity allows the metal to withstand extensive elastic deformations of up to 8% strain without permanent plastic deformation—it is an extremely flexible metal. This characteristic makes nitinol an attractive material for applications where the product needs exceptional flexibility to perform its intended function. The shape memory effect, on the other hand, allows nitinol to fully recover plastic deformation. When heated above a specific temperature, the metal will actually remember its original shape. A nitinol device can be designed to display either or both of these unique properties.

Unfortunately, nitinol also presents some unique manufacturing challenges, particularly related to joining. Since nitinol is comparatively expensive, manufacturers often design products that use nitinol for only the critical elements of a design where the unique properties of nitinol are needed, utilizing other metals for other parts of the design. This design approach requires that the nitinol be joined to a dissimilar metal, such as stainless steel.

Joining nitinol to ferrous metals such as stainless steel has typically proven to be a challenge. Several non-welding methods have been used, including organic adhesives, soldering, brazing and mechanical fastening. Although all of these approaches have been successful to varying degrees, none are necessarily straightforward solutions. In addition, these techniques have serious shortcomings in terms of joint properties or the detrimental impact of the process on the unique properties of the nitinol. As a result, a direct fusion weld between nitinol and stainless steel has long been an attractive alternative.

Despite its desirability, direct fusion welding of nitinol and stainless steel is difficult, if not impossible, due to the formation of brittle intermetallics. These brittle intermetallics weaken the weld so dramatically that it essentially has no mechanical strength, often failing during the welding process itself. One way around this problem is to introduce an intermediate metal or interlayer that is compatible with both nitinol and stainless steel, such as tantalum or niobium. While effective, the disadvantages of this method include the increase in complexity (one weld has now become two), the increased material cost and the potential impact of the interlayer on the function of the assembly.

To help address these welding challenges, EWI has developed a patented technique for direct fusion welding nitinol and stainless steel while avoiding the formation of brittle intermetallics. EWI's approach focused on the use of conventional welding techniques and equipment to ensure widespread accessibility and practicality for manufacturers. EWI engineers developed a patented process that minimizes the intermetallics in the weld metal and dramatically improves weld strength. The process has been successfully demonstrated on wire-to-wire butt joints, with wire diameters ranging from 0.013 to 0.023 in. The weld tensile strengths were increased from zero without the process to 85ksi or more with the process. These weld strengths are high enough to allow full super-elastic bending of the nitinol at the weld. This strength is accompanied by a dramatic reduction in the weld metal hardness from 900 to 450 Vickers hardness, which is comparable to stainless steel wire. This notable hardness reduction is indicative of the dramatic change in the weld deposit metallurgy.

EWI's technique involves the use of a filler metal addition to suppress the brittle intermetallic formation. This filler metal addition is fully consumed within the weld and serves to modify the overall weld metal composition. Figure 1 shows a typical weld made using this new procedure. The weld shown was made using a pulsed Nd:YAG laser. Although this new welding procedure is certainly not limited to laser welding, it provided two key advantages for this application.

First, pulsed lasers facilitate small-scale welds such as these with minimal heat-input and minimal thermal degradation of the nitinol. Second, pulsed Nd:YAG lasers are familiar and already widely used by many manufacturers.

To date, this process has been demonstrated on wire-to-wire butt joint configurations. However, the process is adaptable to many different joint configurations, such as lap joints and tubing joints. The process has demonstrated excellent repeatability and robustness, with successful welds being achieved with every sample produced when controlling the key process parameters.

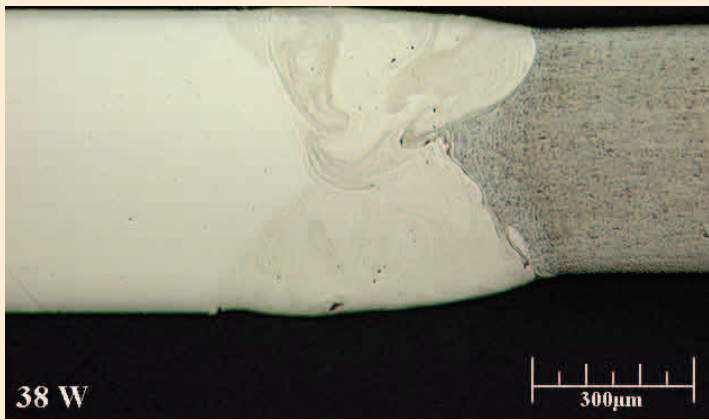
The EWI welding procedure used for nitinol to stainless steel welds has also been demonstrated on similar butt joints between titanium and high-carbon steel wires. This is also a very difficult material combination to weld for the same metallurgical reasons as a nitinol

to stainless steel weld. The successful demonstration of welds between titanium and high-carbon steel illustrates the broader application potential of EWI's new welding procedure beyond nitinol to stainless steel joints.

Welding nitinol to other non-ferrous metals, including welding nitinol to itself, is of great interest to many manufacturers. Welding nitinol to itself is a relatively routine process if good welding practice is followed, including proper cleaning, adequate gas shielding and appropriate heat input control. Some degradation in super-elastic or shape-memory performance at the weld is inevitable, due to grain growth and overheating of the metal just adjacent to the weld, an area commonly referred to as the heat-affected zone. Nevertheless, strong, high-quality joints have been demonstrated by EWI and others using a variety of processes such as laser, resistance, plasma arc and arc percussive welding.

Welding nitinol to other non-ferrous alloys such as Ti-6V-4Al, platinum or tantalum has also been demonstrated. While these welds have not proven to be as challenging as nitinol to stainless steel, great care still must be taken to ensure a good quality weld.

For more information on nitinol joining or other related EWI capabilities, please contact Grant Wilson at 614.688.5093 or [grant\\_wilson@ewi.org](mailto:grant_wilson@ewi.org) or Dan Hauser at 614.688.5124 or [dan\\_hauser@ewi.org](mailto:dan_hauser@ewi.org)



Typical nitinol to stainless weld made with EWI's new process

## Upcoming EWI Tradeshow & Presentations

Dates	Event	Host	Location	Web Site
9/25 – 9/28/05	Materials, Science & Technology	ACerS, AWS, AIST, TMS and ASM International	Pittsburgh, PA	<a href="http://www.matscitech.org">http://www.matscitech.org</a>
9/27 – 9/30/05	ATEXpo	Assembly	Rosemont, IL	<a href="http://www.atexpo.com">http://www.atexpo.com</a>
10/31 – 11/3/05	ICALEO 2005	Laser Institute of America	Miami, FL	<a href="http://www.icaleo.org">http://www.icaleo.org</a>
11/13 – 11/16/05	FABTECH International and The AWS Welding Show	FABTECH and AWS	Chicago, IL	<a href="http://www.aws.org/expo">http://www.aws.org/expo</a>
11/15 – 11/16/05	ASM Materials & Processes for Medical Devices	ASM International	St. Paul, MN	<a href="http://www.asm-intl.org">http://www.asm-intl.org</a>
11/28 – 12/4/05	Defense Manufacturing Conference	ManTech	Orlando, FL	<a href="http://www.dmc.utcd Dayton.com">http://www.dmc.utcd Dayton.com</a>

# New EWI Members

## **II-VI Inc.**

Saxonburg, PA  
Business: Creator of high-tech products for a wide range of applications and industries

## **A & A Industries**

Peabody, MA  
Business: Supplier of precision machining services

## **Albany International Group**

Mansfield, MA  
Business: World's #1 maker of paper machine clothing

## **Alcon Research Ltd./Consumables**

Irvine, CA and Houston, TX  
Business: Manufacturer of eyecare products and surgical equipment

## **Amalgamated Research, Inc.**

Ogden, UT  
Business: Fractal technology for control of fluid dynamics

## **Bellex International Corp.**

Wilmington, DE  
Business: Electronic parts and equipment

## **Bosch Transmission Control Grp.**

Farmington Hills, MI  
Business: Manufacturer of power-train components for automotive industry

## **Canadian Natural Resources,**

Horizon Group  
Calgary, Alberta Canada  
Business: Extraction of oil reserves utilizing both open pit mining and in-situ techniques

## **Cardinal IG**

Minneapolis, MN  
Business: Manufacturer of residential windows and doors

## **CFC Canadoil Inc.**

Houston, TX  
Business: Manufacturer and distributor of pipe & pipe fittings for the petrochemical industry

## **Coe Group**

Painesville, OH  
Business: Provider of machinery and equipment for wood related products industry

## **Creganna Medical Devices, Inc.**

Galway, Ireland  
Business: Minimally invasive medical devices

## **CyberOptics Corp.**

Beaverton, OR  
Business: Optical technology and inspection systems designed to improve yields and throughput in manufacturing processes

## **Duke Mfg. Co.**

St. Louis, MO  
Business: Food service equipment

## **DuPont Engineering & Research Technology**

Wilmington, DE  
Business: Innovative products and services for markets including agriculture, nutrition, electronics, communications, safety and protection, home and construction, transportation and apparel

## **Entrotech**

Columbus, OH  
Business: Design of high performance polymer materials for electronic, medical, aerospace, and transportation applications

## **Ever-Roll Specialties Co.**

Wauseon, OH  
Business: Tube, wire, and rod bending, forming and fabricating using steel, stainless steel, and aluminum tubing, wire, rod and sheet metal

## **Goodrich Corporation**

West Des Moines, IA  
Business: Global supplier of systems and services to the aerospace and defense industry

## **Grote Company**

Columbus, OH  
Business: Manufacturer of food slicing equipment

## **HC Starck, North America**

Cleveland, OH  
Business: Manufacturer of metal powders, semi-finished and finished molybdenum, tungsten, tantalum, niobium, titanium, zirconium and nickel products and their alloys

## **Hisan Inc**

Findlay, OH  
Business: Fluid handling solutions for the automotive industry, including PVDF tubing, copper brazed products, nylon tubing and quick connects

## **Infinia Corporation**

Kennewick, WA  
Business: Developer of free-piston Stirling generators and power systems.

## **International Truck, Cab Assembly & Stamping**

Springfield, OH  
Business: Stamping assembly by an Intelligent Body Assembly System, and painting & finishing of trucks

## **KDI Precision Products**

Cincinnati, OH  
Business: Producer of sophisticated safe and arming devices for missiles

## **Kester, North America**

Des Plaines, IL  
Business: Manufacturer of lead free solutions, solder paste, solid and flux cored wires, and soldering fluxes

## **KUKA Robotics Corporation**

Appleton, WI  
Business: One of the world's largest robot manufacturers

## **L-3 Electrodynamics, Inc.**

Rolling Meadows, IL  
Business: Manufacturer of electronic systems and electromechanical/electromagnetic components

## **Magna International, Inc.**

Ontario, Canada  
Business: A leading global supplier of technologically advanced automotive systems, components and complete modules

## **North Carolina Natural Gas Co.**

Cary, NC  
Business: Regulated retail natural gas distribution in the growing Southeast markets

## **NuTech Engineering**

Ontario, Canada  
Business: Automate MIG, resistance or laser welding application and plasma or laser cutting

## **OPW Fluid Transfer Group**

Skokie, IL  
Business: Design, manufacture, and distribute world class solutions assisting in the safe handling and transporting of hazardous bulk products

## **Panasonic Factory Solutions,**

Welding Division  
Elgin, IL  
Business: Manufacturing/sales of welding robots and equipment

## **Reactive NanoTechnologies Inc.**

Hunt Valley, MD  
Business: Advanced soldering technologies for microelectronic devices and other components at room temperature without the use of a furnace or torch

## **ROL Manufacturing**

Laval, Quebec, Canada  
Business: Manufacturer of exhaust system accessories, gaskets, packing & sealing devices

## **Saint-Gobain Industrial Super Abrasives, Electronic Business Unit**

Worcester, MA  
Business: Superabrasive products for industrial, construction, automotive, and DIY applications

## **Sciaky Inc.**

Chicago, IL  
Business: Manufacturer of standard and controlled welding equipment and systems

## **Southern California Gas Company**

Los Angeles, CA  
Business: Nation's largest natural gas distribution utility

## **Southern Star Central Gas Pipeline**

Owensboro, KY  
Business: Natural gas transmission system

## **Square D Co.**

Oxford, OH  
Business: Manufacturer of electrical and electronic controls, meters, relays, switches, and circuit breakers

## **Triumph Thermal Systems, Inc.**

Forest, OH  
Business: Aerospace heat exchangers and oil reservoirs

## **TRW Automotive, Steering & Suspension, North America**

Sterling Heights, MI  
Business: Manufacturer of power rack and pinion steering gears for passenger cars and light trucks

## **USG Interiors**

Libertyville, IL  
Business: Manufacturer of building products

## **Vehicle Systems Inc.**

Ft. Lupton, CO  
Business: Hydronic heating systems for type-A RV diesel motor homes

## EWI's New Flexible Manufacturing Facility Supports Both Defense and Industrial Applications

EWI has just installed the nation's most advanced flexible welding facility to support the development of innovative joining technologies for defense and industrial applications. The EWI Flexible Manufacturing Facility includes two large welding systems integrated into a single work cell. These welding systems have the capability for friction stir welding, laser welding, arc welding and hybrid-laser arc welding.

The friction stir welding portion of the Advanced Flexible Manufacturing Facility is the largest gantry-style friction stir welding machine in North America. This eight-axis friction stir welding machine has a working envelope that is 24 ft long, 10 ft wide, and 10 ft high and is capable of welding a wide range of structures, including those with complex curvatures. The friction stir welding system was manufactured by the General Tool Company (GTC) of Cincinnati, Ohio. GTC, founded in 1947, provides manufacturing services that support aerospace, aircraft engine, power generation and medical applications for the Department of Defense and a variety of industrial clients. GTC also manufactures complex development hardware.

The gantry robot welding system that is integrated into the Advanced Flexible Manufacturing Facility was manufactured by Hawk Technology, Ltd. (Hawk). Hawk Technology is based in Rock Island, Illinois, where it designs and manufactures robotic and consumer products for a variety of commercial and military industries. Hawk partnered with the Lincoln Automation Group to develop this robot system with nine coordinated axes and a working envelope that is 32 ft long, 14 ft wide and 10 ft high. This system is capable of demonstrating joining technologies such as gas metal arc, laser and hybrid gas metal arc/laser welding on full scale test articles.

Both welding systems share a common Demmeler modular tooling bed that is approximately 19.5 ft long by 13.5 ft wide. Modular tooling will facilitate rapid tool design and set-up. Rapid prototyping strategies will be demonstrated with this equipment by combining modular tooling and offline programming with the capabilities of this manufacturing system.

This flexible manufacturing system is part of two technology development programs funded by the U.S. Army. The first con-

tract from the U.S. Army Research Laboratory (ARL), entitled *Materials Joining for Army Weapons Systems*, is developing advanced materials joining technology to support the Army's Future Combat System (FCS) with particular focus on Manned Ground Vehicles. The second program, the *Advanced Welding Technology Deployment Initiative*, is focusing on producing light-weight prototype structures to support development of advanced weapon systems at the U.S. Army TACOM-ARDEC, Picatinny Arsenal.

Both Army programs support the development of advanced light-weight armor and structural solutions as part of the deployment and survivability objectives of the Army's transformation to the future Objective Force. To facilitate this transformation, the U.S. Army is developing highly agile and lethal vehicles and other systems that are part of the FCS. To meet objectives for reduced weight, the U.S. Army is incorporating a variety of high strength-low density materials such as aluminum, titanium and composites into advanced structural designs. Advanced joining technologies including friction stir welding, hybrid gas metal arc/laser welding, pulsed GMAW, adhesive bonding and active brazing and soldering are being developed to support joining of these advanced materials into hybrid structures.

This Advanced Flexible Manufacturing Facility is a significant addition to EWI's capacity to serve America's defense and industrial manufacturers and broadens EWI's position as the preeminent resource in North America dedicated to advancing and applying welding and joining technologies to benefit industry.

**For more information about the capability of the Flexible Manufacturing Facility or EWI, please contact John Coffey at 614.688.5281 or [john\\_coffey@ewi.org](mailto:john_coffey@ewi.org).**

## EWI

1250 Arthur E. Adams Drive  
Columbus, OH 43221-3585

## Success Story: A. Schulman

### Challenge

A. Schulman Inc. contacted EWI and requested assistance in assessing current manufacturing line production processes. In order to assist A. Schulman in offering process improvements to its customers, EWI conducted a site assessment with A. Schulman at the site of one of the company's customers.

A. Schulman compounds custom polymers. For this particular customer, A. Schulman supplies a polypropylene (PP)-based polymer for residential electrical outlet products. A new assembly process using ultrasonic welding was being beta tested and was nearing approval for full production. EWI was asked to review this process and consider improvements, including transitioning from ultrasonic welding to laser welding of plastic shells.

The EWI objectives for this project were to provide a complete assessment of the current welding process for the electrical outlet components, to review A. Schulman's client's new ultrasonic welding process, to

provide recommendations for process improvements, and to advise A. Schulman on the feasibility of using laser welding.

### Solution

An EWI engineer visited A. Schulman's customer's plant for a one day assessment. Representatives from A. Schulman were in attendance for the plant visit.

The ultrasonic welding process was observed, both in the customer's lab and on the manufacturing floor. The current outlet welding process and materials were reviewed. Discussions were held and included the topics of the product design and ultrasonic welding application as well as the feasibility of using lasers as a welding process.

### Results

EWI's assessment provided A. Schulman and their customer the data they needed for an anticipated economic impact of \$3,000,000 in cost avoidance and 28 jobs saved. "We received the expected value from this project," said Mr. Steve Paolucci, TS&D Specialist-Polyflam, of A. Schulman

Inc. "This was our first opportunity to get into our customer to resolve an issue; our customer was extremely satisfied."

Many factors were taken into consideration when evaluating the client's welding process. Primary categories reviewed included: materials, design, molding, equipment, process parameters, testing, environmental factors, and human resources.

EWI provided A. Schulman with a detailed report of findings and recommendations within one week of the plant visit. EWI's assessment was based on the input provided as a result of discussions, observations, reviews, and all recommendations for improvements.

The report listed many factors that contributed to variations in the overall weld performance. Some recommendations were made, but the overall assessment showed A. Schulman's client's current ultrasonic welding process was efficient and effective for achieving successful results.