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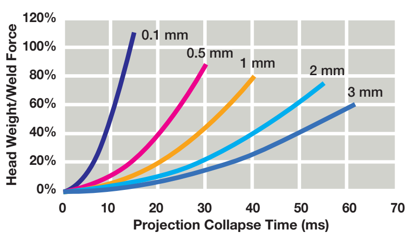
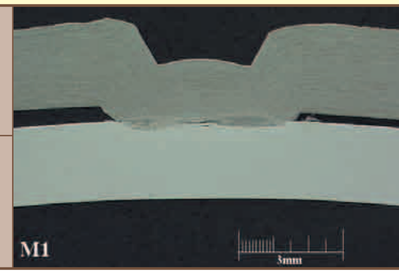
Insights



Relationships between the Head Weight/Weld Force Ratio and Projection Collapse Time for a Range of Collapse Distances

The result of the projection weld.



Recent Advances in Projection Welding

Jerry E. Gould | Principal Engineer, Resistance and Solid State Welding

Projection welding is a resistance based process that utilizes geometrically configured localized contact to promote heating and subsequent joining. The most common variations of the technology are those that use either a stamped or machined projection (the current concentrating protrusion) to facilitate the localized contact. Projection welding, in any of its forms, has largely been restricted to steels and stainless steels. Application to other materials has been problematic. Recent work at EWI has focused on understanding requirements for projection welding and using these requirements to extend the process to other material systems.

A major concern in projection welding is the ability of the welding head to maintain force throughout the process. This is generally described as the follow-up characteristic of the system. Poor follow-up, in the extreme, can result localized melting of the projection, with loss of weld quality. This basic problem has been a major limitation to the application of projection welding to both thin gauge materials as well as a wider range of material systems.

Follow-up requirements for projection welding can be expressed in terms of simple dynamics. Essentially, for the force applied, the weld head must be light enough to maintain force through an acceleration profile matching the collapse of the projection. The ratio of weld head weight to applied welding force, while maintaining at least 95% of the contact load, can be expressed as:

$$\frac{W_{head}}{F_{app}} \leq \frac{g(ft)^2}{20x}$$

Where W_{head} is the weight of the weld head and tooling, F_{app} is the applied welding force, g is acceleration due to gravity, t is the weld time, f is the fraction of weld time for projection collapse and x is the total projection collapse distance.

The results of this expression can be expressed as a series of curves representing critical W_{head}/F_{app} ratios for various collapse times and distances. These results show that shorter collapse times and larger collapse distances make design of the weld head progressively more critical. Collapse times and distances, however, are largely defined by the application. Steels, for example, typically exhibit collapse times on the order of 10–30 ms for best practice joining. Aluminum, with its higher conductivity, shows required collapse times on the order of one third of that required for steels.

These results have been used to develop weld heads specifically for aluminum applications. Such weld heads use internal springs with moving weights as specified from the equation above. Resulting projection welds show clear forging at the tip, and subsequent bonding with the base metal. Such detailed analysis of the projection welding process is facilitating its use in applications as diverse as aluminum attachments to nickel base superalloy assemblies.

For additional information on the recent advances in projection welding or how EWI can help you maximize this process for your specific applications, please contact Jerry Gould at 614.688.5121 or jerry_gould@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 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.

Henry J. Cialone

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.

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). Questions relating to an article may also be directed to the contact listed in the article.

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EWI Awards

Please join EWI in congratulating several employees on their selection by the AWS Committee to receive the following awards:

Bill Bruce

Harvey Castner

Nancy Porter

Wei Zhang

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) 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 demonstrated 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) 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.

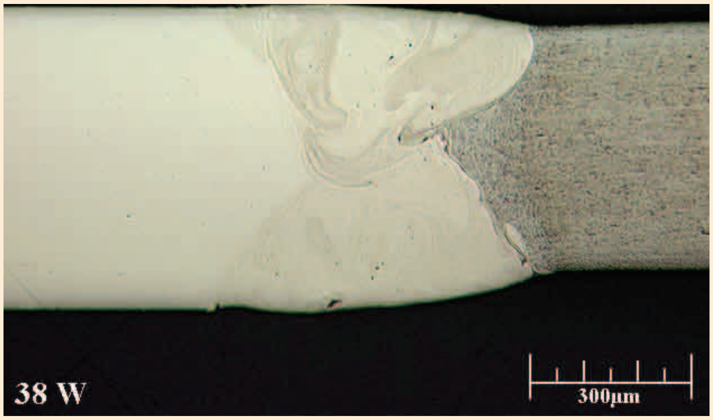
To help address these welding challenges, EWI has developed a patented technique for direct fusion welding nitinol and stainless steel while avoiding the formation of brittle intermetallics. EWI's approach focused on the use of conventional welding techniques and equipment to ensure widespread accessibility 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.



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

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 or Dan Hauser at 614.688.5124 or dan_hauser@ewi.org

Upcoming EWI Tradeshows & Presentations

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

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 powertrain 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 contract 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 lightweight 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 lightweight 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.

Insights

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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.