

Reducing Manufacturing Costs with Resistance Welding

Hheavy equipment producers continually search for ways to reduce manufacturing costs. Current areas of interest include attachment of embossments as well as torque transmission components with resistance projection welding in lieu of conventional fusion welding.

The application of resistance projection welding can result in per part cost savings of over 90%. Solid projection welding, annular projection welding in particular, has been used in the automotive industry for decades. Over the last 10 years, the consistency of such welds has been greatly enabled by better understanding of the process, advances in equipment control, and improvement in steel quality. Today, the process is capable of producing high strength, highly consistent joints.

Solid projection welding, used for attaching solid components to sheets is similar to embossed projection welding, used for sheet-sheet attachments. Procedures for selecting projection geometries, and processing conditions for embossed projection welding are well established, and are published in a range of recommended practice documents. Similar recommendations for solid projection welding have traditionally not been available. Recently, EWI has conducted a research program to develop a recommended practice for annular projection welding. Work was conducted to assess the effects of a range of projection designs and process conditions on the performance of annular projection welds.

These results were used to develop this recommended practice for annular projection welding. The projection design and processing guidelines can be used with intermittent or continuous projections, and are intended for use with mild steel components. These guidelines are approximate and should not be considered optimal. The guidelines presented here can, and should, be modified to adapt to any particular application.

For more information on resistance projection welding, contact EWI's Jerry Gould at (614) 688-5121 (jerry_gould@ewi.org).



Projection Welded Drive Hub



Macrosection of a Mild Steel Annular Resistance Projection Weld

Derived recommended practice guidelines for annular resistance projection welding mild steel. These guidelines include, as a function of the underlying steel gauge, recommendations for projection geometry and welding practice.

Recommended Practice Guidelines for Solid Annular Projection Welding of Mild Steel						
Material Thickness (in.)	Projection Height (in.)	Projection Angle (included <)	Projection Position (in.)	Weld Time (cycles)	Weld Current (kA/linear in.)	Weld Force (lb/linear in.)
0.030	0.020	90	0.005	8	14	731
0.040	0.024	90	0.006	9	14	900
0.050	0.028	90	0.007	10	15	1050
0.060	0.032	90	0.008	11	15	1181
0.070	0.040	90	0.010	11	15	1500
0.080	0.048	90	0.012	11	16	1800
0.090	0.056	90	0.014	12	16	2100
0.100	0.064	90	0.016	12	17	2400
0.125	0.072	90	0.018	12	17	2700
0.150	0.084	90	0.021	14	18	3150
0.175	0.096	90	0.024	16	20	3600
0.200	0.108	90	0.027	18	22	4050
0.225	0.120	90	0.030	19	24	4500
0.250	0.132	90	0.033	20	26	4950

Position Included > Height



Investing in Technology

Albert Einstein once said, "I never think of the future – it comes soon enough." Not so at EWI. An essential part of our mission is to anticipate, develop, and refine the next generation of joining technologies that our members will need. Most of our members – who are fully occupied with the present – place a high value on EWI's role in anticipating technology developments and making them accessible for competitive advantage.

While some people claim to have a crystal ball that reveals the most pressing technology needs in the next three to five years, no one really does. Like our members, EWI is constantly gathering and evaluating information about new materials joining technologies in order to make the right selections for investments.

EWI does this by keeping a close watch on research developments and matching them against business drivers in each of our industry sectors. No matter how interesting a particular development may be in the laboratory, its real potential is realized only when it matches an existing or emerging need. The secret

to selecting the right targets for investment is to know our customers' business and technology drivers as well or better than they do.



We are in the process of refining our technology investment plans. EWI Market Leaders have been calling and visiting members to help in this process. With

this input and our own analysis, we have developed preliminary investment roadmaps for the aerospace, heavy manufacturing, defense, energy and chemical, and medical/microelectronics industries. We are now reviewing our findings with senior industry engineering and R&D contacts, actively soliciting your feedback and experience-based input. Once this process is complete, we will share the results with our Industry Advisory Board and use it to formulate EWI's Cooperative Research Program (CRP) for the fiscal year 2005.

If you haven't heard from us yet, feel free to contact me at 614-688-5222 (ted_ford@ewi.org) with your comments or feedback. We will get in touch with you to talk further and ensure we fully understand your suggestions.

Ted Ford, President and CEO

NEW MEMBERS

CryoCath Technologies, Inc.
Kirkland, Quebec
Business: Manufacturer of catheter based cryotherapy equipment.

EGC Enterprises, Inc.
Chardon, OH
Business: Manufacturers of gasket, packaging, and sealing devices.

Ecodyne MRM, Inc.
Massillon, OH
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Business: Producers of under-hood air conditioning tube and hose assemblies.

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Business: Manufacturer of vinyl windows and patio doors.

Stix International
Staten Island, NY
Business: Development of water resistant chemical coatings.

Valeo Wiper Systems, North American Division
Auburn Hills, MI
Business: Manufacturer of wiper motors, sensors, arms, and blades.

Insights is produced four times per year. Please direct general questions and comments to Heidi Wilson, Marketing Communications Manager, at (614) 688-5130 (heidi_wilson@ewi.org). Questions relating to an article may also be directed to the contact listed in the article.

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Control of Weld Distortion and Accuracy Benefits Navy Ships, Marine Corps Armored Vehicles, and Commercial Applications

The Navy Joining Center, operated by EWI, has extensive experience in reducing weld distortion during the fabrication of Navy ships and of Marine Corps combat vehicles. This includes development of finite element analysis tools to predict distortion as well as practical welding procedures to control distortion.

One of these procedures is a patent-pending thermal tensioning technique to control buckling of thin steel panels for ship bulkheads and decks. NJC distortion control technology also supports overall improvement in accuracy control of ship construction.

Technology developed by the NJC has been utilized in a wide range of applications:

- Shipyards have applied this technology to DDG-51, LHD-1, and LPD-17 class ships.
- Control of weld distortion resulted in cost avoidance of over \$1 million on each DDG-51 destroyer.
- The thermal tensioning technique was successfully used for production of panels at NG Ingalls Operations.
- Distortion analysis and control tools helped the Marine Corps Advanced Amphibious Assault Vehicle program reduce costs for tooling, in-process fabrication, and rework.
- The NJC has extended the technology to commercial applications. One company reduced its scrap rate, due to distortion, from 60 percent to zero with a corresponding significant reduction in manufacturing costs.
- Cost savings over a five year period are estimated to exceed \$21 million, yielding a return on investment of more than 10:1.



For more information on reducing weld distortion during the fabrication of Navy ships and of Marine Corps combat vehicles, contact EWI's Harvey Castner at (614) 688-5063 (harvey_castner@ewi.org).

EWI Steps Up to the Challenge of Fuel Cell Manufacturability

Background

Fuel cell systems promise to be to this century what computer chips were to the last century. Fuel cells promise to power the products and devices that will be used in the Information Age: portable devices (electronics), transportation vehicles (cars), and stationary products (homes).

As basic fuel cell technologies mature, the challenge will be to integrate advanced fuel cell materials into the precision fabrications required for fuel cell performance. It will be necessary for the industry to manufacture cells, stacks, and systems in very high production volumes. If the fuel cell industry is to achieve the product sales projections

that are necessary to make it a viable industry, billions of fuel cells will need to be manufactured, assembled into hundreds of millions of fuel cell stacks, and built into millions of fuel cell products. The challenge is to achieve computer-chip manufacturing volumes and quality, with the electrochemical materials and the thermal, fluid, electrical, and mechanical processes implicit in fuel cell operation.

Fuel cells are vital to the future energy independence of the U.S. and represent a key element in the continued improvement of the environment. Economical fuel cell devices provide a national benefit, giving the U.S. alternatives to central electric power plants regarding the use of coal and nuclear energy, and options for the transportation sector regarding the use of imported oil. Consequently, Federal Agencies are funding fuel cell development ranging from fundamental scientific exploration to full scale hardware demonstration programs. EWI is contributing to the direction of these programs.

States like Ohio, where EWI is headquartered, are investing in its manufacturing and industrial base to be a major contributor to the fuel cell industry, producing jobs and stimulating economic development while providing the supply-chain infrastructure that a new industry needs to flourish. EWI is participating in the Fuel Cell Power Partnership of Ohio.

Considerable private capital and public research funding is also being devoted to the numerous technical and business challenges associated with fuel cells. EWI is working with its member companies on the development and manufactur-

ability of fuel cell stack components and fuel cell system balance-of-plant components.

The Challenge of Manufacturing Fuel Cells

The challenge lies in translating the science of fuel cells into engineered devices and products. The nationwide market for these products is projected to grow into the billions of dollars if the price points of the manufactured product can be met.

Fuel cell power systems are currently as much as 10 to 100 times more expensive than they must be to achieve their projected market growth. To gain broad acceptance it is crucial to reduce the unit cost of fuel cell systems, while simultaneously improving commercial product performance and reliability.

Meeting these major challenges requires:

- focused investment and effort in the design for inexpensive mass-manufacture
- sophisticated manufacturing and materials processing technologies
- adaptation of existing production and assembly approaches to highly integrated fuel cell systems
- development of non-destructive testing and evaluation techniques to support high volume production

EWI's materials joining, non-destructive evaluation, and manufacturing capabilities will play a significant role in bringing economical fuel cell products to market sooner.

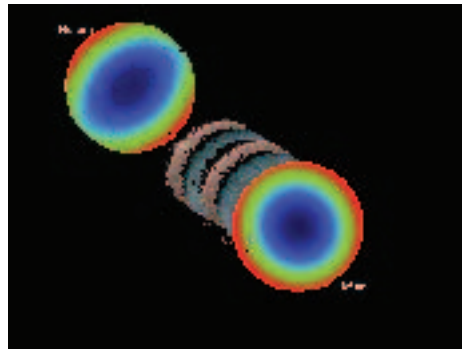
Solution

Through its internal research program EWI is exploring ways to improve the manufacturability of fuel cells, fuel cell stacks, and fuel cell system components. In addition, EWI has a specific program underway to develop modeling techniques, imaging techniques, and material property data.

The Team

EWI's Fuel Cell Industry Team is led by Frank Jakob, Market Leader for fuel cells. He is assisted by the following team:

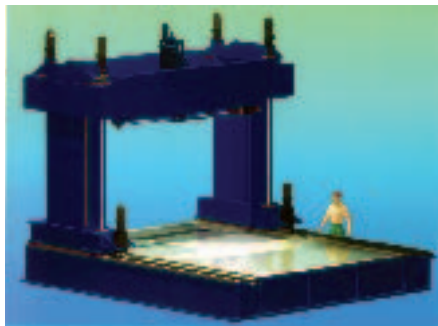
- Stan Ream, Market Leader, Automotive and Light Manufacturing
- Matt White, Market Leader, Heavy Manufacturing
- Pete Hall, Principal Engineer, Micro-joining & Plastics



Examples of color coded surface height profiles being developed for the ceramic and metal surfaces within solid-oxide fuel cell stacks.

EWI Growing Capability With Friction Stir Welder

EWI will be able to offer its customers the nation's most advanced friction stir welding capability with a new \$1 million machine to be manufactured by General Tool Co. of Cincinnati. The funding comes from a \$22 million, five-year cooperative agreement between EWI and the U.S. Army Research Laboratory.



The new machine will be the largest gantry type machine available in North America, with a working envelope of 10 feet by 10 feet by 16 feet. The length can be increased as customer needs require. The machine has a seven-axis capability, which will allow the machine to join components with complex curvature. In addition to the FSW features, the machine will also feature a high speed machining capability to prepare the components for welding and perform post weld finishing operations. The new unit will provide EWI with a multifunction technology platform, and will be installed in a factory setting to develop, demonstrate and transition advanced joining the FSW process for a variety of applications.

EWI is a leader in development of friction stir technology that has applications in the automotive, aerospace, heavy manufacturing, and defense industries. General Tool Company (GTC), founded in 1947, provides manufacturing services that support

a large number of aerospace, aircraft engine, power generation, and medical for the department of defense and a variety of industrial clients. GTC also manufactures complex development hardware.

"Friction stir welding is a revolutionary solid state joining technology, which has been one the most critical emerging technologies over the past 10 years," said Harvey Castner, director, EWI's government programs office. "This is a cornerstone technology to growing our business."

EWI is currently working with the U.S. Army and Industry to define

potential applications for friction stir welding to support the Army's Future Combat System (FCS) with primary emphasis on the manned ground vehicle program (MGV). The current industry partners include Boeing, Sikorsky, Lockheed Martin, General Dynamics, United Defense and GE Aircraft Engines.

How it works

Friction stir welding (FSW) is a joining process in which a rotating shouldered tool is plunged into adjoining materials. Frictional heat generated during this process causes the materials to soften and local plastic deformation to occur. The softened material is stirred together from the rotation process resulting in a solid state bond with excellent mechanical properties. The technology allows materials previously considered non-weldable, such as certain types of aluminum, titanium, stainless steel, nickel, and thermoplastics to be joined.

In late 2002, the Army purchased a smaller laboratory version FSW machine with similar features. The machine is now in operation at EWI's Columbus facility and is being used to develop and demonstrate advanced FSW technologies for the FCS. The machine is also being used to demonstrate the FSW process for military aircraft engine and airframe applications.

For more information on the Friction Stir Welding Machine, contact EWI's Harvey Castner at (614) 688-5063 (harvey_castner@ewi.org).

EWI Steps Up to the Challenge of Fuel Cell Manufacturability (continued from page 4)

- John Lawmon, Principal Engineer, Arc Welding, Materials & Automation
- John Metscher, Account Manager, Membership
- Bob Kratzenberg, Market Leader, Government Programs Office

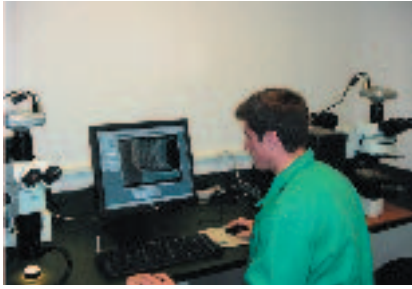
For more information on fuel cell manufacturability, contact EWI's Frank Jakob at (614) 688-5069 (frank_jakob@ewi.org).

What is a fuel cell? ...

A fuel cell is a device that converts energy in a fuel (typically hydrogen available from hydrocarbon fuels) directly into electric power efficiently without combustion and with few emissions. Fuel Cell products promise long-lasting battery replacements, efficient and clean engines for vehicles, and reliable power and heat for buildings.

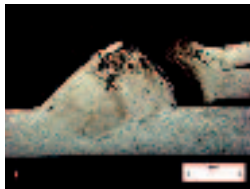
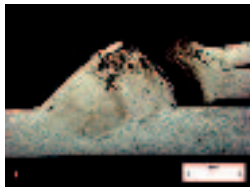
At the heart of any fuel cell system is an individual cell capable of producing 0.5 Watt/cm² at 0.75 Volt. Multiple cells must be configured into "stacks" of cells to provide power levels and voltage levels that are usable: 5 Watts for a laptop computer, 1,000 Watts (1 kW) for a home, 75kW for a car, and up to a few megawatt for a commercial building.

EWI Installs State-of-the-Art Digital Microscopy System



To better serve its customers, EWI recently installed a state-of-the-art digital microscopy system.

This system is comprised of a digital microscope with infinity-corrected optics, with magnification capabilities ranging from 12.5x to 1000x and a digital stereoscope with a magnification range of 3.5x to 45x. Additionally, the system has been coordinated with a conventional macro stand. Ultimately expanding our capabilities from approximately 0.5x to 1000x.



Infinity-Corrected Optical Systems were first developed and implemented on research microscopes. Their commercial robustness has gradually increased since their introduction, to the point that they are now considered the premier optical system for biological and industrial research microscopes.

These optic systems have two key advantages over the previous finite or fixed tube optical systems. The first is the ability to insert auxiliary components, such as differential interference contrast (DIC) prisms, polarizers, and epi-fluorescence illuminators, into the parallel optical path between the objective and the tube lens with only a minimal effect on focus and aberration corrections. Secondly, these infinity-corrected optics allow for longer objective lens distances. This allows for higher efficiency optics, because more light is able to enter the object lens at lower angles of entry.

Along with the obvious technological advancements, the benefit of one inclusive system to take digital photos on the entire range of macro- and microscopic images is that the entire range of capabilities is calibrated and upgraded together. EWI is proud to offer the bi-products of this cutting edge equipment to its members.

For additional information, please contact EWI's Margaret Hiermer at (614) 688-5136 (margaret_hiermer@ewi.org).

EWI Conducted Workshop Session at the March, 2004 Automotive Laser Applications Workshop Conference in Plymouth, Michigan

In recent years tremendous research attention has been devoted to the science and technology of fuel cells intended for applications ranging from power generation to automotive propulsion. Far less attention has been devoted to developing the manufacturing technologies that fuel cell production demands. For the many joining situations presented by the wide range of fuel cell system designs, lasers are emerging as a frequent tool of choice. The unique challenges and opportunities for the application of lasers in future fuel cell manufacturing were explored at the Automotive Laser Application Workshop (ALAW), in EWI's fuel cell manufacturing session, titled The Future of Lasers in Fuel Cell Manufacturing.



The Future of Lasers in Fuel Cell Manufacturing took place Monday, March 8, 2004 from 1:30 – 4:00 pm at the St. John's Conference Center in Plymouth, MI. The session was chaired by Stanley Ream, Automotive Market Leader of EWI. Mr. Ream's 30 years of industrial laser applications experience provide him with

a broad view of the challenges ahead for this emerging joining challenge.

Through this unique perspective and EWI's broad exposure to a great variety of joining challenges, this session provided direction for those interested in pursuing fuel cell manufacturing opportunities. Presenters include technology suppliers, joining researchers, and fuel cell industry representatives.

For more information on EWI's fuel cell expertise, contact Stan Ream at (614) 688-5092 (stan_ream@ewi.org).

NJC Developing Adhesive Bond Data for Design of Aircraft Primary Structures

The Navy Joining Center (NJC) is performing a Navy MANTECH project with the Air Force and Composite Affordability Initiative (CAI) to characterize manufacturing variabilities that affect adhesive bonding for composite joints used in the fabrication of aircraft primary structures. To meet Navy aircraft service requirements for bonding of primary composite structures, it is necessary to develop adhesive joint mechanical property data to quantify the effects of manufacturing variability in adhesive bonded systems. This project is being accomplished by EWI and several airframe manufacturers.

Adhesive bonded primary aircraft structures have the potential to save significant weight and cost over conventional bonded/riveted or bolted joint designs. New bonded joint designs have been developed, as part of the Core Technology Plan for the CAI program, which minimize peel stresses and provide a more robust joint.

The joint, commonly referred to as Pi (π) or tongue-and-groove joint, offer a male and female section bonded with a paste adhesive. This type of joint can be used on both structural connections and on closeout connections to complete a sub-assembly (i.e. skin-to-ribbed box composite structure). Even though the Pi-joint configuration has the potential to improve the performance of adhesively bonded joints, there are issues that must be evaluated to insure they can be reproducibly manufactured for primary structure.

As a complement to earlier CAI activity, this project was identified to address manufacture "scale-up" and testing of adhesive-bonded joints under operational conditions. Large Pi-joint fabrication test elements are being manufactured to include a variety of process variables. Test specimens are being produced from the large Pi-joint test elements in sufficient number to provide data on shear loading, combined-angle loading, and fatigue performance.

To date, a number of manufacturing variables have been identified by the airframe manufacturers and tests have



Figure 1. JSF F-35 composite inlet duct design

been performed quantifying their effects on adhesive-bonded joints. Manufacturing variables under investigation for adhesive bonding are surface preparation, bondline thickness, offset web, porosity, and cure cycle. Initial data results have been released to both Navy and Air Force and the CAI community for review. The initial data is being used by designers for bonding of composite structures in the Joint Strike Fighter (JSF) program. Figure 1 shows the application of bonding technology on the inlet duct assembly for the JSF. Testing is continuing for other applications for advanced aircraft structures.

The results of this project will support the Navy and Air force requirements for future adhesive bonded aircraft structures for enhanced performance and operation costs. In addition, the CAI will be provided with data to support certification efforts, design specifications, and manufacturing processes to aid in maturing the technology. As the reliability of adhesive bonding is confirmed, both the Navy and the airframe manufacturers will encourage the use of this joining technology for primary structures.

For more information, contact George Ritter, EWI at (614) 688-5199 (george_ritter@ewi.org) or Larry Brown, NJC at (614) 688-5080 (larry_brown@ewi.org).



Upcoming Trade Shows & Presentations

3/8-3/11/04
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 University of Michigan
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www.engin.umich.edu

3/9-3/11/04
MedTec
 Canon Communications
 Stuttgart, Germany
www.deviceink.com/expo/medtec04/index.html

4/6-4/8/04
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 American Welding Society
 Chicago, IL
www.aws.org

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 SAE International
 Wichita, KS
<http://www.sae.org/calendar/gat/>

5/4-5/6/04
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TWI Bulletin Vol. 45 #1 Jan/Feb 2004

TWI Connect Issue #127 Nov/Dec 2003

TWI Connect Issue #128 Jan/Feb 2004

TWI Report #769 Constraint Calculation in Pipeline Girth Welds

TWI Report #770 Qualifying Long-Term Performance of Butt Fusion Welds in PE Pipes for Short-Term Tests

TWI Report #771 Pulsed MIG Arc Welding Processes for Joining of Thin Sheet Aluminum

TWI Report #772 Process Guidance and Software for Clearweld®

TWI Report #773 Corrosion Testing of Aluminum Alloy Friction

TWI Report #774 A Survey of Welding and Repairing of Nickel Superalloys for Gas Turbines

TWI Report #775 A Review of Models for Simulation of Material Flow During Friction Stir Welding

TWI Report #776 A Study of Arc and Friction Stir Welding of Two Al Alloys Containing a Low Level Scandium Addition