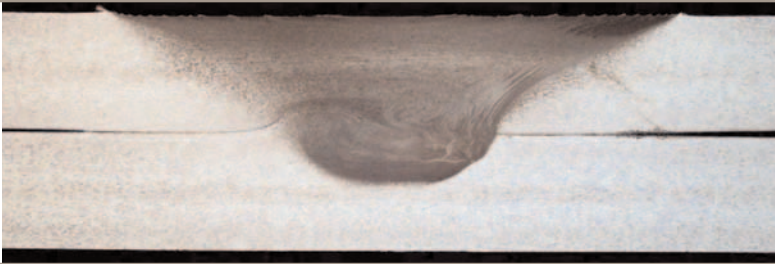


Insights



◀ Macrograph of 0.080-in. thick 7075-T7 FSW lap joint with a sealant

Advanced Welding Processes for Aluminum Aircraft Structures

Jerry Gould | Principal Engineer

Aluminum aircraft structures are predominantly manufactured from high strength aluminum alloys. These include the 7xxx, 6xxx, and 2xxx classes of alloys. Specific materials include AA 7075, AA6013, and AA 2024. These aluminum alloys are either considered non- or difficult-to-weld using conventional arc welding processes. Historically, such structures are assembled with mechanical fasteners. Such fasteners are expensive to install and have low joint efficiencies.

Friction stir welding (FSW) has become attractive for the replacement of these fasteners, especially fuselage and wing box. The cost analysis in the Metals Affordability Initiative (MAI) program has shown that replacing riveting with FSW will reduce joining costs by 20% and shorten manufacturing lead-time by 25%.

Moreover, static lap-shear strengths of FSW lap joints are more than double that of riveted joints. Fatigue strengths are improved as well. Recent work at EWI has

also combined FSW with adhesives/sealants. This approach has resulted in corrosion resistant high efficiency joints in the aircraft structures.

More recently, efforts have been made to apply laser welding to these materials in combination with cold wire feed fillers. Cold wire feed allows alloying of the weld pool while maintaining the penetration and productivity benefits of the laser welding process. Efforts to qualify these welds have been quite successful. In fact, the Airbus A380 will have over 5,000 square meters of laser welds (with filler), attaching stiffeners to skins. Analogous to the friction stir welding case, development of this process can be justified through reduced costs (compared to mechanical fasteners) and improved joint efficiencies.

There are concerns with combining cold wire filler metal and laser welding for aluminum. In particular, it is very difficult to position the wire in the proper location for

welding, and laser power is required to melt the filler. EWI has been successful in developing a laser/GMAW hybrid process for welding aluminum. Welds up to 6 mm thick have been accomplished using this approach. This has been successful at lower laser power levels and at higher welding speeds than can be achieved with the cold wire approach. This new processing approach also permits welding in thicker sections of aluminum with reduced heat affected zones and distortion.

For more information on welding processes for aluminum aircraft structure, contact Jerry Gould at 614.688.5121 or jerry_gould@ewi.org.

The President's Corner

As 2006 gets started, one of EWI's challenges will be to outpace the accomplishments realized in 2005. While the past year certainly qualified as a transition year at EWI, it didn't lack for notable achievements. From a year-in-review perspective, I'm quite proud of the people, events, and milestones that contributed to a memorable year. Attempting to top 2005 will make 2006 an interesting journey.

The past year ended on a high note for EWI when the United States Department of Defense granted us the Defense Manufacturing Technology Achievement Award for the Navy Joining Center project on composite-to-steel adhesive joints for the DD(X) destroyer. Earlier in the year, our Government Programs Office Vice President, Harvey Castner, was honored as an AWS Fellow and awarded a National Meritorious Award and the Health and Safety Award from AWS. We also hosted several technology workshops on Ultrasonics, Magnetic Pulse, Advanced High-Strength Steel, and a Technology Overview workshop. EWI was issued five patents over the course of 2005 in weldbonding, adaptive and synergic fill welding methods, welding of nitinol to stainless steel, a nondestructive butt weld inspection method, and reduction of distortion by transient thermal tensioning.

Both our virtual "front door" and our bricks-and-mortar front door were recently spruced up to better welcome website and building visitors to EWI. I hope you've had an opportunity to visit www.ewi.org and "surf" the newest version of the site. With better organization of information and navigation, and new content additions, we think you'll find the site both practical and pleasing. And, while we realize that not all of our members can visit us on a regular basis, we think those who are planning a visit to Columbus in



Henry J. Cialone

the future will be equally impressed by the enhancements made in our lobby and meeting spaces.

The year also brought about changes to the EWI Code and our Board of Directors. We simplified the Code and streamlined the Board, changes which were passed unanimously at a special meeting of Members on December 12. The Board was

reduced from 16 to 9 members and the Executive Committee was eliminated, while regular meeting frequency was increased from 4 to 6 times per year. Our overall objectives were to improve the corporate governance of EWI and make EWI a more effective service provider for its Members, able to adapt more rapidly to changing market demands and Member needs. I invite you to contact me directly with your comments as to how well we are meeting that standard of performance.

The past year has been a time of accomplishment and progress. In the new year, we look forward to building on our successes and embracing the challenges and opportunities ahead. And, as always, we encourage you—our membership base—to continue to let us know how we can better meet your needs.



EWI Names Mark Matson as Human Resources Director



Mark Matson

EWI announced that Mr. Mark Matson joined EWI as Human Resources Director. Mr. Matson's responsibilities include the development and implementation of all phases of talent management practices as well as the alignment of those practices with business strategies.

Mr. Matson is certified by the Society for Human Resource Management (SHRM) as a Senior Professional in Human Resource Management (SPHR). He received his Master's degree in Labor Relations and Human Resource Management from the Fisher College of Business at The Ohio State University. He holds a

Bachelor's degree in Urban Studies from The Catholic University of America in Washington, D.C.

Mr. Matson has been an active leader in community and professional organizations. He has served on the Advisory Board for the Institute for Management Studies based in Reno, NV and the National Certification Standards Committee for the Society for Human Resource Management in Washington, D.C. He is an active community leader with the Central Ohio United Way, most recently serving on their Race and Diversity Vision Council. He has served as a Trustee for the Columbus Literacy Council, as a Trustee and President for Rebuilding America/Ohio, and as a community educator for the Columbus AIDS Task Force.

Congresswoman Deborah Pryce Visits EWI

Visit Focuses on EWI's Advanced Welding Technology Deployment Initiative

Ohio Congresswoman Deborah Pryce recently visited EWI to review the innovations in advanced joining processes brought about by the \$3.8 million contract awarded to EWI in early 2004 to establish the Advanced Welding Technology Deployment Initiative (AWTDI).

The visit, which took place on Monday, December 12, included remarks by Congresswoman Pryce, a tour of EWI's manufacturing lab area, and a ribbon cutting ceremony for EWI's new flexible manufacturing cell.

Matt White, Market Leader for EWI's Government Programs Office, stated, "Through the funds provided by AWTDI, EWI has procured a flexible fabrication cell capable of combining several joining processes with rapid design and tooling. EWI will make extensive use of its modular tooling, computer modeling, and offline programming capabilities to meet a range of defense applications."

White continued, "In the case of the Army's upcoming Future Combat System, the flexible fabrication cell will be used to incorporate low-density, high-performance materials such as aluminum, titanium, and composites into advanced structural designs to reduce weight. Combining these materials to produce hybrid structures requires a number of advanced joining technologies including friction stir welding (FSW), hybrid gas metal arc/laser welding, pulsed gas metal arc welding (GMAW) of titanium, adhesive bonding, and active brazing/soldering."

The AWTDI program provides cutting edge welding and joining techniques to rapidly produce improved armored vehicle armor systems using composites, ceramics, titanium, and aluminum and improve the manufacturability and repair of current systems. It was initiated to assist the Army and its manufacturing base in responding to changing threats to U.S. forces in Iraq and Afghanistan, as well as the need for lighter-weight, rapidly deployable weapons systems to meet the challenges of the war on terror.

For more information on the AWTDI, please contact Matt White at 614.688.5241 or matt_white@ewi.org.



Deborah Pryce Visits EWI



Flexible Fabrication Cell at EWI

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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Adhesive Bonds and Titanium

For many years, the use of expensive materials such as titanium has been limited to high performance aerospace applications where the performance justifies the high raw material cost. More recently, performance requirements in other applications have led to increasing interest in titanium alloys in the automotive, heavy manufacturing, and medical industries.

To form a durable adhesive bond to titanium, the surface must be treated to produce a strongly bound, stable oxide layer.

Traditionally, this was done using either strong acid or strong base often in an electrochemical cell (anodization). These treatments are relatively slow and require the use of hazardous chemicals. In order to broaden the use of titanium in non-aerospace industries, the development of an effective, user-friendly, environmentally benign pretreatment will be required. As part of a new transportation program, EWI has recently revisited several simple surface treatment options for titanium bonds to aluminum.

The stiffness of titanium and its alloys coupled with its excellent heat resistance made it an attractive component of airframe structure for more than 40 years. During the development of the high speed commercial transport in the 1970s and 1980s, a substantial effort was invested in developing bonding technologies for titanium and its alloys, especially titanium 6/4 (6% aluminum: 4% vanadium). While anodization and acid treatments such as Pasa-Jell (PRC-DeSoto) were frequently used, it has since been found that the solubility of the titanium oxide in the bulk metal increases at high temperatures so the oxide surface has a tendency to disappear into the bulk under use conditions. This has necessitated the development of several plasma deposition treatments to produce a heat stable bonding surface on titanium. For applications which do not require high temperature durability, anodization and strong acid pretreatments have remained the standard for preparing titanium surfaces although the best surface preparation seems to vary depending on the particular adhesive composition employed.

Since the use of environmentally friendly processes is increasingly attractive in most industries, we undertook an investigation of more benign surface treatment options for titanium 6-4. This desire led us to look at the performance of alkaline hydrogen peroxide as a pretreatment. Peroxide had been one of the first surface treatments used on titanium and its alloys, but its use has not been recently investigated. We also found that dental fluori-

dating gel might provide a safer alternative to aggressive phosphate fluoride treatments.

Several surface treatment options were screened using the wedge test ASTM 3762. All of the surfaces were primed with BR 127NC

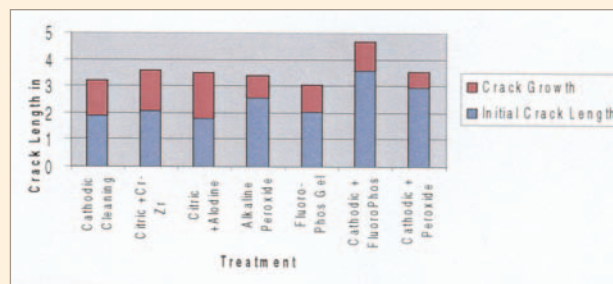


Figure 1. Wedge Test Results for Ti-Ti Bonds with Different Surface Treatments.

after the pretreatment. Two adhesive cure schedules were examined: 30 days at room temperature and 14 days at room temperature followed by a 70°C post cure for 60-90 minutes. Crack growth was measured initially and after seven days at both normal room conditions and under 60°C/100% relative humidity exposure. The results are shown in Figure 1.

From these experiments, it was clear that both the alkaline peroxide and the dental fluoro-phos gel performed well. Both the initial crack length and the growth after seven days were low for both treatments. Both of these treatments were further investigated by preparing type A double lap shear specimens according to ASTM D 3528. For these specimens, the outer plates were treated titanium while the inner plate was aluminum. The thicknesses of the plates were adjusted to compensate for the stiffness of the titanium. The strength of these samples was determined at both room

temperature and upon moisture saturation after aging 60 days at 60°C and 100% RH. The strength results are shown in Figure 2. The strength and environmental resistance of the bonded joints was comparable to that of a soldered joint as shown in Figure 3.

Both alkaline peroxide and dental fluoro-phos gel performed well as pretreatments for titanium 6-4 under these testing conditions. The relative success of the treatments appears to vary depending on the cure of the adhesive. Since the properties of the bond adhesive appear to depend on the interaction of the adhesive with

the surface treatment, further investigation of these simple surface preparations with other adhesive formulations would be useful.

For more information about adhesive bonding at EWI, log on to the Members Only portion of the EWI web site where the latest adhesive/bonding reports have been posted on your personalized homepage. You may access the members only site at www.ewi.org/members/ or contact George Ritter at 614.688.5199 or george_ritter@ewi.org, or contact David Speth at 614.688.5162 or david_speth@ewi.org.

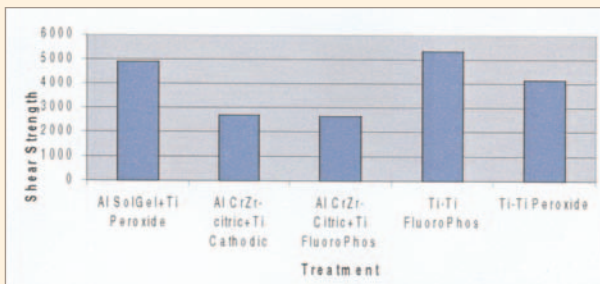


Figure 2. Double Lap Shear Strengths for Al-Ti and Ti-Ti Bonds.

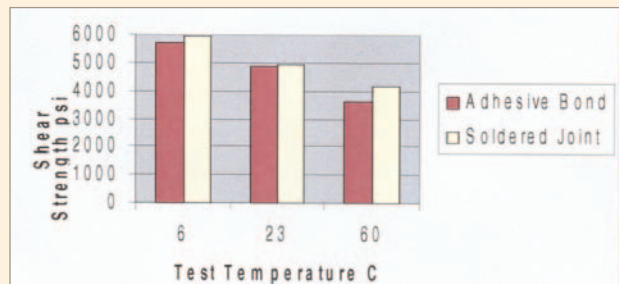


Figure 3. Comparison of Strength between Adhesive Bond and Soldered Joint

Upcoming EWI Tradeshow & Presentations

Dates	Event	Host	Location	Web Site
3/29 - 3/30/06	Automotive Laser Applications Workshop	Univ. of Michigan	Plymouth, MI	http://cpd.engin.umich.edu/
4/25 - 4/27/06	Maintenance, Repair & Overhaul Conference and Exhibition	Aviation Week	Phoenix, AZ	http://www.aviationnow.com/conferences/mromain.htm
5/9 - 5/12/06	Sheet Metal Welding Conference XII	American Welding Society	Detroit, MI	http://aws.kukausa.com/
5/15 - 5/18/06	Aeromat Exposition	ASM International	Seattle, WA	http://www.asminternational.org/seattle/index.htm
5/23 - 5/24/06	Ohio Fuel Cell Symposium	Ohio Fuel Cell Coalition	Canton, OH	http://www.fuelcellsohio.org/pages/831560/index.htm

EWI Helps U.S. Bridge Retain Employees

U.S. Bridge is the largest manufacturer of permanent steel truss bridges for secondary roads in the country. In 2002, U.S. Bridge observed a crack in one of its trusses after hot-dip galvanizing. A thorough inspection of other trusses returned from the galvanizer as well as trusses recently erected disclosed that the problem began to occur that summer. This was a highly unusual condition not previously experienced, and the company's engineers were unable to determine the cause. Had the source of this problem not been identified, the survival of U.S. Bridge, together with 150 much needed local jobs, would have been in jeopardy.

Having nowhere else to turn, the company consulted EWI, where it is a long-standing member. After a methodical laboratory analysis, EWI's engineers identified the cause to be the presence of tin in the zinc ingots recently purchased by the galvanizer. This caused liquid metal embrittlement. Armed with that study, U.S. Bridge required its galvanizer to change its zinc bath and the problem did not recur.

EWI also provided U.S. Bridge with a process for repairing the existing cracks. As part of this process, an updated inspection procedure was developed so that U.S. Bridge could more effectively inspect its galvanized trusses to catch any future

problems prior to installation. By identifying a systemic problem, the results of this work greatly benefited the entire bridge construction industry, not only U.S. Bridge.

Arthur Rogovin, President of U.S. Bridge, has stated that EWI's expertise saved his company from likely disaster and preserved 150 local jobs. The savings represented an over 15:1 return on the money invested in the project.

For more information on U.S. Bridge analyzing and repairs, please contact Mike Merlo at 614.688.5149 or mike_merlo@ewi.org.

EWI and OSU Collaborate on Ultrasonic Weldability Study



As part of a year-long senior project, a group of Ohio State University Welding Engineering students have teamed with EWI to better understand the weldability of materials when using the ultrasonic metal welding (UMW) process. Working on a senior year "Capstone" project, OSU students Matthew Bloss, Jeremy Brooks, Matthew Pischel, and Kerry Shook are coordinating their efforts with Haiping Shao and Karl Graff, Senior Engineers at EWI.

Ultrasonic metal welding is finding increased applications, or potential applications, in automotive and aerospace structures and medical and electronic products, as well as in emerging technologies such as ultrasonic additive manufacturing. In all of these areas, the continued drive is to weld materials, combinations and thicknesses that have not previously been welded, or for which there is no reliable welding data. Existing ultrasonic metal weldability charts pro-

vide, at best, an uncertain starting point as to materials and combinations that might be weldable, and provide no guidance as to weld process parameters. The weldability study, expected to extend for several years, is intended to remedy these problems.

The first year of this program will focus on determining the weldability of a number of Al (e.g. 2024, 3XXX, 5XXX, 6XXX and 7XXX) alloys, as well as Cu and Mg alloys. The program will also establish standardized welding procedures (e.g. ultrasonic parameters of vibration amplitude, energy and clamping force), surface conditions and tooling, as well as mechanical and metallurgical test procedures. Testing will progress to increasingly difficult-to-weld materials, including stainless steels, titaniums, and various advanced aerospace alloys.

Initial testing will be done using EWI's 20 kHz AmTech Ultraweld 20 ultrasonic metal welder. It is anticipated that welders of increasing power levels, exceeding 5kW, will be used as testing of more challenging alloys is undertaken.

Dr. Graff, overall project leader, believes the benefits of the work will have far-ranging impact, providing the basis for wider use of the ultrasonic metal welding process. "It's an ideal example of OSU-EWI cooperation, generating needed data for our industrial customers, and also providing a valuable training ground for some of the next generation of welding engineers."

Virtual Reality Welding Training Demonstrated at Defense Manufacturing Conference

The Navy Joining Center (NJC) recently demonstrated an innovative approach to welder training at the Defense Manufacturing Conference. The first-of-a-kind virtual reality welder training system permits the trainee to hold an actual welding torch while seeing and hearing a virtual weld being created. The virtual reality training system was developed to train welders for submarine construction, but the technology is immediately transferable to other shipbuilders and defense manufacturers. The project team includes EWI, General Dynamics Electric Boat, and VRSim.

An aging workforce is opening a gap in the availability of skilled welders for ship construction. Virtual reality technology is already being used for training in medicine, aviation, law enforcement, and the military. The virtual reality welder training tool created in this project will drive down training costs and improve training efficiency.

The project created a prototype system, comprised of a head-mounted 3-D display and welding torch attached to a force feedback device. The simulation of the welding process is based on numerical models validated with actual welds made with shipyard welding procedures. The welding process and resultant weld bead are displayed in a virtual environment and on a separate monitor for the welding instructor. Weld quality and recorded process parameters are displayed after welding for critique and instruction.

Evaluations of the system by more than 100 users confirmed that it is easy to use and provides a reasonably realistic experience. The system is already being commercialized by VRSim and their partner Silicon Graphics Inc. (SGI).

For more information on virtual reality welder training, please contact Nancy Porter at 614.688.5194 or nancy_porter@ewi.org.



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New EWI Members

ALSTOM Power Inc., Energy & Environment Systems (EES) USA
Windsor, CT
Business: Manufacturer of power plant equipment, boiler-steam generators & turbines

Conor Medsystems, Inc.
Menlo Park, CA
Business: Developer of vascular drug delivery technologies

Fuel Total Systems California Corp. (FTSCA)
Lathrop, CA
Business: Manufacturer of plastic fuel tanks

Hughes Christensen Co.
Houston, TX
Business: Manufacturer of drill bits for the petroleum industry

Kensey Nash Corp.
Exton, PA
Business: Design, development, and manufacturing of absorbable medical devices

Kiswel Co., Ltd.
Duluth, GA
Business: Manufacturer of welding consumables

M.K. Morse Company
Canton OH
Business: Manufacturer of saw blades and accessories

The NanoSteel Company
Maitland, FL
Business: Manufacturer of steel products

Pemery Corp.
Broadview Heights, OH
Business: Developer of fuel cell technology

Tracewell Systems, Inc.
Westerville, OH
Business: Electronics and systems integration