METALWORKING TECHNOLOGY Update

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Project Profile

NMC Builds Generic Ship Innerbottom Page 2

Technology Focus

Abrasive Waterjet Cutting Page 4

What's New

NMC Takes the Lead on Low-Cost Friction Stir Welding for LCS Page 6

Advanced Metalworking Solutions for Naval Systems that Go in Harm's Way

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Concurrent Technologies Corporation (*CTC*) operates the Navy Metalworking Center (NMC) for the U.S. Navy Manufacturing Technology (ManTech) Program. NMC serves as a national resource for developing and implementing advanced technologies for metalworking products and processes. NMC applies these technologies to improve cost and performance in support of Navy and Department of Defense needs.

NMC offers extensive expertise in metal-working technologies, materials, and related processes. If you are interested in pursuing a project consistent with the capabilities listed below, please contact
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- metals and advanced metallic materials
- metal-based composites
- ceramics
- metallic materials-based systems
- metal/non-metal interface issues
- primary metal materials manufacturing processes
- shape-making processes
- joining techniques
- surface and heat treatments
- metalworking systems engineering activities
- materials characterization and testing
- process design and control
- product design and structural performance
- environmental issues and recycling
- information and data handling and transfer
- manufacturing technology/industrial base infrastructure

For further information about topics in this publication, please contact 717-565-4405.

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Page 3: Howitzer photo courtesy of U.S. Navy.
Page 4: Waterjet cutting photos courtesy of Spiritech, Incorporated.
Page 6: LCS courtesy of Lockheed Martin Corporation.

Project Profile

NMC Builds Generic Ship Innerbottom

The remediation of distortion caused by welding adds considerable cost and time to ship construction. Distortion can be removed after welding by flame straightening, but this requires experienced personnel using a trial-and-error solution method. Significant cost savings could be achieved by performing iterations on the welding process and sequence in a computational model, instead of on physical mock-ups or actual structures. However, commercially available computational models for predicting weld distortion have not been applied to the types and sizes of structures encountered in shipbuilding.

The generic ship innerbottom measures 12.5-ft. by 11.5-ft. by 5-ft. and will be used to verify two weld distortion analysis software programs.

The Navy Metalworking Center (NMC), under the "Manufacturing Process Development for Elimination of Weld Distortion of CVN 21 Heavy Plate Erection Units" project, is building a test article to help determine the applicability of commercially available predictive weld distortion software to ship construction. Team members include Battelle Memorial Institute (BMI), ESI North America (ESI), and Optimal, Inc. The NMC project is coordinated with the "Predictive Weld Distortion in Thick Navy Structures" project, managed by the Center for Naval Shipbuilding Technology (CNST), with project lead Northrop Grumman Newport News (NGNN).

The test article is a 12.5-ft by 11.5-ft by 5-ft portion of a full-scale, generic ship innerbottom. The steel plate thicknesses are similar to commercial construction and the materials, which are used in Navy construction, are 1-inch thick HSLA-100 and ½-inch and ¾-inch thick HSLA-65. The weld sequence of the structure was designed to maximize the induced distortion for comparing with the welding simulation.

Two weld distortion analysis software programs, BMI's VFT™ and ESI's SYSWELD®, are being used to simulate the welding process based on the welding parameters for the as-built structure. To verify each program's capability, the distortion predicted by the software is being compared against the actual weld distortion indicated by measurement data. NMC will coordinate the results of this verification with the CNST project results to arrive at an assessment of the applicability of predictive weld distortion modeling to ship construction. ■

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Mark Your Calendar

NMC-Facilitated Events

ShipTech 2007, January 30–31, 2007, Beau Rivage Resort, Biloxi, MS, www.nmc.ctc.com

Friction Stir Welding Workshop: Technology for Defense Applications, February 21–22, 2007, Navy Joining Center/Edison Welding Institute, Columbus, OH, www.nmc.ctc.com

Watch for Our Exhibit–Booth 415

DMC 2006, November 27–30, 2006, Gaylord Opryland, Nashville, TN, www.dmc.utcdayton.com/index.htm

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A Face Behind the NMC Name: Wm. Troy Tack

In this continuing series, NMC is recognizing the people who solve current metalworking problems, work everyday to improve weapons systems for the U.S. Navy and DoD, and are committed to the success of the Program.

As Principal Staff Member for *CTC*, Troy Tack solves technical problems, provides consultation, and plays a key role in the success of the multiple ManTech projects. Most recently, Troy served as the project manager for the highly successful "Improved Affordability of Titanium Components for Marine Corps' M777 Lightweight 155mm Howitzer" project (see adjacent article). This project will realize nearly $40 million in cost savings over the low rate initial production and full rate production phases.

Troy and his project team also developed a plan to unify two problematic steel castings in support of the lightweight howitzer program. He currently manages the "Metallic Materials Advanced Development Certification" project and is developing several new projects, including Advanced Combatant Materials, that support various Navy platforms.

Troy began his career at Lockheed Martin where he managed an R&D project to develop aluminum-lithium alloy 2195. Lockheed Martin then leveraged the alloy into a $350 million contract award to build the Space Shuttle's External Tank, accomplishing a weight savings of 8,000 pounds. Troy received the highest honor at Lockheed Martin, the Jefferson Cup, and was named Corporate Author of the Year. He was also employed as Vice President of Technology Sales at Ashurst and as a consultant to Fansteel's chief executive officer (CEO).

Troy has presented at various technical conventions throughout the U.S. He was also invited by Lockheed Martin CEO Norm Augustine to brief Lockheed corporate headquarters on an R&D project and a special Department of Defense program.

The holder of four patents, Troy earned an M.S. in Materials Engineering and a B.S. in Metallurgical Engineering from Colorado School of Mines. ■

NMC Improves Affordability of LW155 Howitzer

The completion of the LW155 Howitzer project comes with marked success, capitalizing on NMC's strengths of development, process optimization, and technology transition. The Lightweight Howitzer Program is a joint effort between the U.S. Marine Corps and the Army to replace aging steel-intensive M198 155mm howitzers. The NMC project, which began in July 2002, supported the development of this titanium-intensive system by reducing part count, manufacturing cost and material waste. The use of titanium alloys in place of steel reduces the weight of each gun from 16,000 to 9,000 pounds, resulting in substantial improvements in transport logistics and weapon set-up time.

NMC worked with the Lightweight Howitzer Joint Program Management Office of Picatinny Arsenal, BAE Systems and titanium foundry PCC Structurals to develop single-piece investment cast spades, which stabilize the howitzer during firing. The project team reduced the part count from 60 to one by creating a single spade casting that replaces expensive, labor-intensive machining and welding processes. The cast spades were implemented in full rate production, which began in March 2005.

A marine loads the LW155 Howitzer.

The project also demonstrated a 110 to one reduction in part count of the saddle and the development of alternative sources of raw materials and novel production paths to eliminate machining-intensive production processes.

Benefits of the project include expected cost savings of $27 million for the single-piece investment cast spades, qualification of low-cost input materials that will further reduce costs, and 68% cost savings for the flowformed tube as opposed to baseline production methods. The expansion of the vendor network for the cradle tubes has enhanced the supply redundancy for the program and will see a cost avoidance of $13 million over the full-rate production contract.

The project received the highest rating in eight of nine categories on a contract feedback survey, and the quality of the products and services of the project were cited as being "of excellent quality with detailed documentation." The Lightweight Howitzer project was also commended by the Joint Defense Manufacturing panel on two occasions and was highly rated by the Metals Processing and Fabrication portfolio review team.

Technology transfer opportunities also exist in other DoD programs that depend on low-cost structural titanium alloys for reducing system weight while improving the performance of components. ■

Spiritech Works to Develop New Waterjet Technology

NMC is working with Spiritech, Incorporated on the "Mobilized Abrasive Waterjet Cutting" project for the Office of Naval Research. The project is developing a mobile abrasive waterjet-cutting system prototype for shipyard demonstration and implementation. The project team includes Penn State University/Applied Research Laboratory Repair Technologies (REPTECH), Norfolk Naval Shipyard, Puget Sound Naval Shipyard, Portsmouth Naval Shipyard, Pearl Harbor Naval Shipyard, and Naval Sea Systems Command (NAVSEA).

Waterjet cutting applications are numerous.

Repair, maintenance, and restoration of shipboard structures and components often require removal of structures to obtain access to the area of interest. Currently, oxy-fuel or plasma arc torches are used for this process on U.S. Navy ships in dry-dock. However, the use of this process generates high temperatures, which can result in undesirable thermal distortion and metallurgical effects, risk of fire, residual stress and other damage in the material being cut as well as in other areas adjacent to the repair.

The use of abrasive waterjet-cutting technology in dry-dock applications is limited because typically workstations are used to process parts within the manufacturing process line. This makes it difficult or impossible to work in "on-site" situations, such as a ship hull, because the object being cut cannot be accommodated by the workstation.

In order to take advantage of the benefits of waterjet-cutting technology a mobile abrasive waterjet-cutting system is being developed for demonstration and implementation. The system will allow shipyards to apply and further develop the technology for specific applications and requirements.

Spiritech, Incorporated Waterjet Cutting Technologies is located in Johnstown, Pennsylvania, and specializes in waterjet and abrasive waterjet-cutting services. ■

Abrasive Waterjet Cutting

Background

Waterjet technology is one of the fastest growing machine tool processes in the world. With applications as broad as automation, food processing, surface preparation, and waterjet cutting, the growth potential is immense.

When water is pressurized up to 50,000 pounds per square inch or more and forced through a small jet, it can cut a variety of soft materials including food, paper, baby diapers, rubber, and foam. When abrasive particles, such as garnet or sand, are mixed into the jet stream, the resulting "abrasive waterjet" erodes the material and can cut metal, composites, stone, and glass. Abrasives are screened and sized for different materials and jobs. Abrasive waterjets can cut materials with hardness up to and beyond aluminum oxide ceramic.

Waterjet cutting is a precise, environmentally sound cutting option with many benefits over traditional cutting.

The cutting process allows materials at various thicknesses to be stacked, which makes the process productive and efficient. The method generates a high-quality finish, similar to a sandblast finish on most materials. High-grade sand as the abrasive results in a clean process with environmentally sound waste products and no environmental impact.

Different styles and configurations of waterjet-cutting equipment exist. Besides providing motion, the typical machine tool also includes a means to hold the material being cut and collect the water and debris.

Benefits

The benefits of abrasive waterjet cutting include:

- Reduced potential for fire or fumes – This process eliminates potential for fire hazard and the need for fire watches.
- Improved surface finish quality – Waterjet-cutting technology is more precise and eliminates post-process finishing.
- Reduced re-work of plate – The ability to cut without causing distortion allows reuse of the components or plates.
- Reduced patch preparation process time – Current patch preparation process time may be dramatically reduced or possibly eliminated.
- Improved post-cut properties – This process provides post-cut properties such as near net shape, low distortion and a no heat-affected zone.

Applications

The Navy currently uses abrasive waterjet cutting to cut ship building materials. It can be used for thicker plate materials, dissimilar materials, composite, and other non-metallic parts and welded components as well as components with variable thickness. ■

Daniel L. Winterscheidt

"The foundation of the NMC Program is based on some very basic principles, and it is important to do them right to ensure that we successfully implement the technologies developed under our projects."

As Program Director for the past three years, I've learned that there are many details associated with the management of a Navy ManTech Center of Excellence, and addressing them correctly—from the very beginning—is critical to the success of our projects and the NMC Program. This conclusion became even more evident after the award of the new Navy Metalworking Center contract, where great effort was put into contract modifications and requirements for task orders, award fee, subcontractors, and technology transition plans.

Through it all, though, I've gained renewed respect for the fundamentals, and I'm reminded of a quote by John Wooden, the legendary basketball coach of the UCLA Bruins: "If you don't have time to do it right, when will you have time to do it over?"

The foundation of the NMC Program is based on some very basic principles, and it is important to do them right to ensure that we successfully implement the technologies developed under our projects. Teamwork, customer focus, understanding stakeholder needs, developing trust and respect, and providing sound technical solutions are among the attributes that guide our center.

Our LASCOR project exemplifies the need to focus on the basics and to establish the groundwork for transition from the very start. For the past 20 years, the Navy has endeavored to achieve large-scale implementation of LASCOR—stiff, lightweight metallic-sandwich panels that may be a viable alternative to reduce weight and cost on CVN 78. There are a number of challenges, and many individuals and organizations are involved in the development of the technology. We believe that it is critical to build trust among the members of the Integrated Project Team (IPT), which includes PEO Aircraft Carriers, NAVSEA, Carderock, NGNN, Applied Thermal Sciences, NJC and iMAST. Equally important is the need to establish buy-in for the project from the members of the team. Other fundamental factors that are key to LASCOR's success include quantifying the use of LASCOR on a CVN application and meeting critical design dates, which prove that we are focused on the client and understand their needs. Establishing a domestic supplier and selecting the appropriate material also demonstrate our technical role. All of these contributions will impact the likelihood of LASCOR's transition.

These basic principles were executed on our M777 Lightweight Howitzer project, which is currently being implemented by the Joint Program Management Office (see Page 3). As we move forward with our new Low-Cost Friction Stir Welding of Aluminum project for LCS (see Page 6), we understand that the foundation of a project is built on the basics, and when we take care of the basics, we will establish trust and respect within the IPT, and ultimately, develop a friction stir welding system that can be utilized on site at the shipyards.

Frequently, it's the day-to-day, often mundane, and sometimes tedious attention to detail that ensures that we have the foundation in place for successful technology implementation. Coach Wooden's persistence and emphasis on discipline made him the most successful coach in the history of college basketball. I, too, believe that unwavering focus on the fundamentals is the key to NMC successfully accomplishing its primary goal: transitioning advanced metalworking solutions for naval systems that go in harm's way.

Daniel L. Winterscheidt

Daniel L. Winterscheidt, Ph.D.
Program Director
Navy Metalworking Center

Manufacturers Improve Performance of Welding Electrodes for Joining Ship Steels

In 2004, NMC initiated a project to address the optimization of MIL-10718-M shielded metal arc welding (SMAW) electrodes, which are used in welding HSLA-100 and HY-100 steels. This electrode had a history of inconsistency and rejection at the shipyards. The project identified process improvements that have allowed manufacturers to produce electrodes with consistent mechanical properties. Now, shipyards can procure and utilize consistent 1/8-inch MIL-10718-M electrodes that meet the required performance in welded HSLA-100 and HY-100 steels.

This project is a team effort among NMC, PMS 378 Future Aircraft Carriers Program Office, Naval Surface Warfare Center–Carderock Division (NSWCCD), NAVSEA Technical Codes, General Dynamics Electric Boat (GDEB), Northrop Grumman Newport News (NGNN), ESAB Welding and Cutting Products (ESAB) and Lincoln Electric (Lincoln). To increase flexibility and provide an additional diameter electrode, the project team is working to develop 3/32-inch MIL-10718-M electrodes. In addition, NSWCCD is working with the electrode producers and shipyards to standardize conformance test conditions to reduce electrode lot rejections.

For this project, the two electrode manufacturers, ESAB and Lincoln, each produced three lots of 1/8-inch diameter and three lots of 3/32-inch diameter electrodes and provided them to GDEB and NGNN for verification of operating characteristics, weld metal mechanical properties, electrode usability, and welder appeal. Prior to shipment, the electrode manufacturers successfully demonstrated conformance of these lots to the requirements of Technical Publication T9074-BC-GIB-010/0200. Shipyard testing shows that all lots of 1/8-inch electrodes met the requirements of the technical publication while providing good usability and welder appeal. Testing of the 3/32-inch electrodes is in progress, but results to date indicate that the electrodes meet the specification requirements.

The success of this project ensures consistent availability to the U.S. military and military contractors of two diameters of MIL-10718 electrode needed for cost-effective production of naval vessels, including VIRGINIA (SSN 774) submarines, CVN 21 aircraft carriers and DDG 1000 surface combatants as well as for effecting repairs of existing systems. ■

NMC Takes the Lead on Low-Cost Friction Stir Welding for LCS

NMC has initiated a friction stir welding (FSW) project for the Littoral Combat Ship (LCS), the Navy's new focused-mission surface combatant. "Low-Cost Friction Stir Welding of Aluminum for LCS Applications" will design and build the first low-cost FSW machine and evaluate the costs and benefits of implementing FSW. NMC is working with an integrated project team comprised of the LCS Program Office, Lockheed Martin, Marinette Marine Corporation, Bollinger Shipyards, NAVSEA, and the American Bureau of Shipping.

LCS incorporates significant amounts of aluminum. FSW is an ideal joining process for aluminum and provides vast improvements over conventional marine aluminum construction methods because it offers decreased distortion, improved joint properties, and reduced production costs.

"Friction stir welding has seen very limited application in U.S. ship construction," said Dr. Daniel L. Winterscheidt, NMC Program Director. "By demonstrating the construction of large, representative aluminum structures, NMC can enhance the quality of the joining process with the use of FSW in the shipyard, reduce acquisition costs of future programs, and increase the utilization of FSW throughout the industry."

The NMC project will design, build, and demonstrate a transportable FSW system that will be housed at the shipyard. By limiting the design's functionality to the specific needs of LCS, the machine will be much less costly and provide a quicker return on investment for the shipyard. The simpler machine will require minimal site preparation and be sized for mobility among and within shipyards. By locating the FSW operation at the construction yard, the benefits of FSW can be more fully realized because the panels will be built to the size needed for construction, rather than limited to a panel size for transportation. The machine's simplified controls and operation also reduce the skill set and technical support required for the operator.

LCS is an entirely new breed of U.S. Navy warship – a focused-mission surface combatant.

In a separate effort for LCS, NMC also identified state-of-the-art pipe bending capabilities in support of Bollinger Shipyards' Lockport LCS efforts. Specifically, NMC determined pipe spool design software and equipment interface capabilities as well as the functionality and availability of pipe bending equipment for a variety of pipe sizes and schedules pertinent to the LCS design. ■