Advanced Metalworking Solutions

For Naval Systems That Go In Harm's Way

2010 Annual Report

Navy Metalworking Center

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14. ABSTRACT
Alloy 625, a nickel-based alloy, is difficult to form, particularly at room temperature. A Navy Metalworking Center (NMC) project minimized potentially significant schedule delays for the construction of the CVN 78 aircraft carrier by identifying optimal forming practices for Alloy 625 in several critical components as well as by evaluating the corrosion performance of the Alloy 625-to-HSLA (high strength, low alloy) steel welds. Using the project findings, Northrop Grumman Shipbuilding-Newport News (NGSB-NN) was able to form several complex shapes on the first attempt and in sufficient time to support the production schedule for these critical components. The project results minimized the risk of cracking this very expensive material, which would not only delay the production schedule but would also add cost to re-manufacture these shapes. This project supports the efforts to attain the desired benefits of Alloy 625 and to achieve an extended life cycle for Navy ship seawater cooling system designs. NMC worked with an Integrated Project Team (IPT) consisting of NGSB-NN, Naval Surface Warfare Center Carderock Division (NSWCCD), and the Future Aircraft Carriers Program Office to progress this technology.

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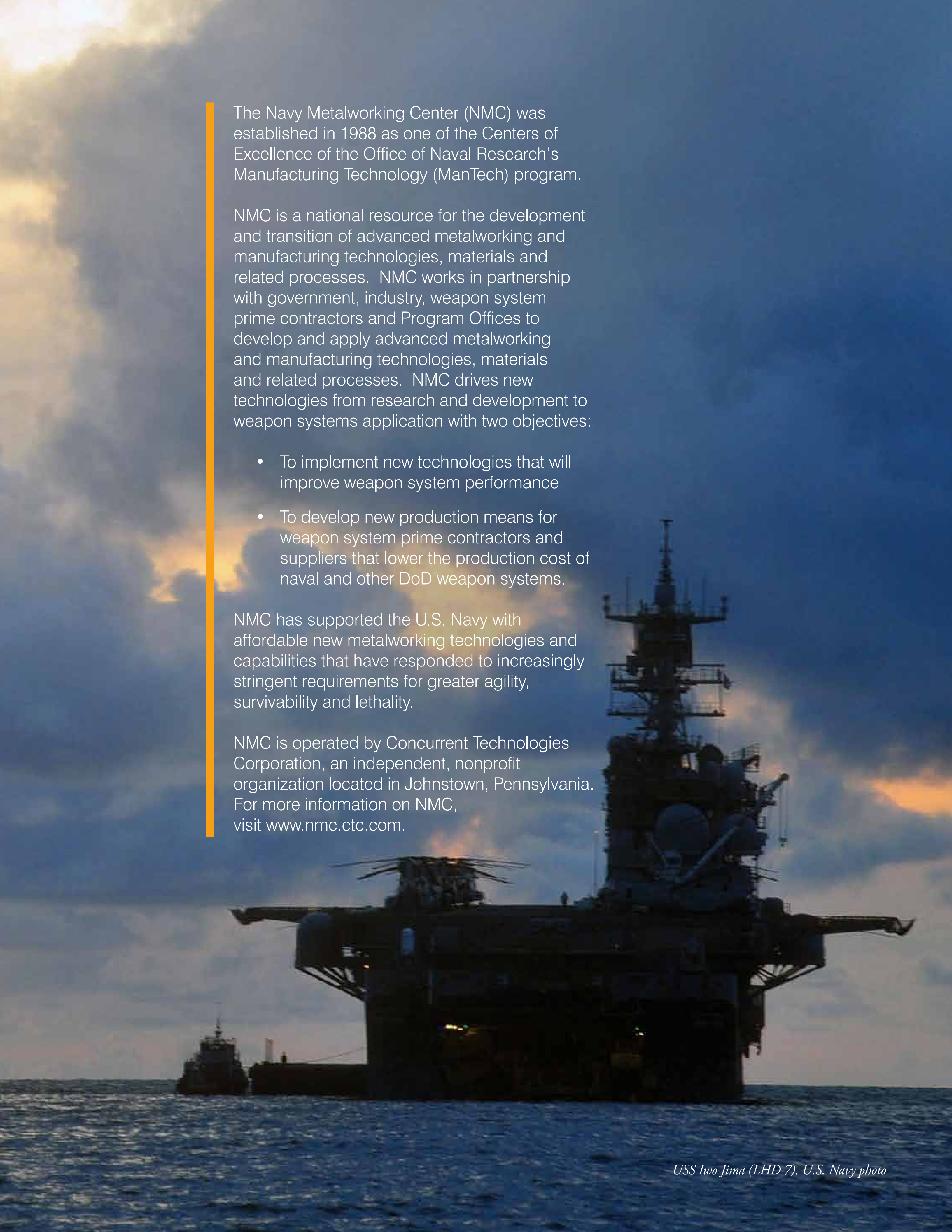
The Navy Metalworking Center (NMC) was established in 1988 as one of the Centers of Excellence of the Office of Naval Research's Manufacturing Technology (ManTech) program.

NMC is a national resource for the development and transition of advanced metalworking and manufacturing technologies, materials and related processes. NMC works in partnership with government, industry, weapon system prime contractors and Program Offices to develop and apply advanced metalworking and manufacturing technologies, materials and related processes. NMC drives new technologies from research and development to weapon systems application with two objectives:

- To implement new technologies that will improve weapon system performance
- To develop new production means for weapon system prime contractors and suppliers that lower the production cost of naval and other DoD weapon systems.

NMC has supported the U.S. Navy with affordable new metalworking technologies and capabilities that have responded to increasingly stringent requirements for greater agility, survivability and lethality.

NMC is operated by Concurrent Technologies Corporation, an independent, nonprofit organization located in Johnstown, Pennsylvania. For more information on NMC, visit www.nmc.ctc.com.



USS Iwo Jima (LHD 7). U.S. Navy photo

DIRECTORS' LETTERS

Navy Metalworking Center Program Director Dan Winterscheidt (left) and Office of Naval Research Manufacturing Technology Program Director John Carney (right).

Project implementation and transition remain the focal points of the Navy ManTech Program. This past year, Navy ManTech expanded its goals to add total ownership cost (TOC) to acquisition cost savings as a means of improving the affordability of Navy weapon systems. TOC started out as a focus area for the Virginia Class Submarine, and we now apply it to the other platforms we support, including CVN 78, DDG 1000/DDG 51 and the Littoral Combat Ship.

In this report, you will read about a number of projects that the Navy Metalworking Center has performed that address our affordability goals, including the Weld Seam Facing project. The project developed a mechanized tool that removes 80% of the weld reinforcement at rates exceeding 20 feet per hour and was successfully implemented by Bath Iron Works in the construction of DDG 51 and DDG 1000. The tool will reduce the construction cost of DDG 1000 by $2.77M and significantly decrease the number of injuries and resulting medical expenses incurred from manual hand grinding. The tool was also modified to perform back gouging and was used by BIW on DDG 1000 and is planned to be used by Northrop Grumman Shipbuilding – Gulf Coast.

Navy ManTech is making a difference, and efforts like the WSF project are good examples of why we are getting well-deserved recognition. I congratulate Dan Winterscheidt and his team for winning the contract to continue managing and operating NMC. I look forward to working with NMC over the next five years on projects that further reduce acquisition and total ownership cost and that improve the manufacturability of Navy weapon systems.

John U. Carney
Director, Manufacturing Technology Program
Office of Naval Research

2010 was a good year for NMC. A number of our projects transitioned to industry and will save millions of dollars for the Navy. One such project, the Weld Seam Facing and Back Gouging project, was the recipient of a 2010 Defense Manufacturing Technology Achievement Award for its development and commercialization of a weld shaver system that has wide applicability for multiple Navy shipyards as well as many Department of Defense weapons systems. We also received special commendation from the Joint Defense Manufacturing Technology Panel Metals Subpanel for our extra effort and outstanding track record of transitioning projects to industry. And in August, CTC was awarded a five-year, competitively bid contract to continue operation of the NMC Program.

A few things come to mind when I think about our recent successes: teamwork, trust, dedication, and innovative, yet practical technical solutions. I also think about our strong focus on the Navy's needs and expectations, particularly acquisition cost savings and now total ownership cost reduction. What's interesting is that the fundamentals remain the same regardless of whether a project is implemented and viewed as successful. Our commitment to the Navy does not falter. Teamwork, trust, dedication, and technical solutions are intrinsic.

In the coming decade, the Navy will face even greater manufacturing and affordability challenges, and we are even more committed to working with our Navy and industry partners to meet the new challenges. The Navy Metalworking Center is looking forward to the next five years and to the continued development and implementation of advanced metalworking solutions for naval systems that go in harm's way.

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

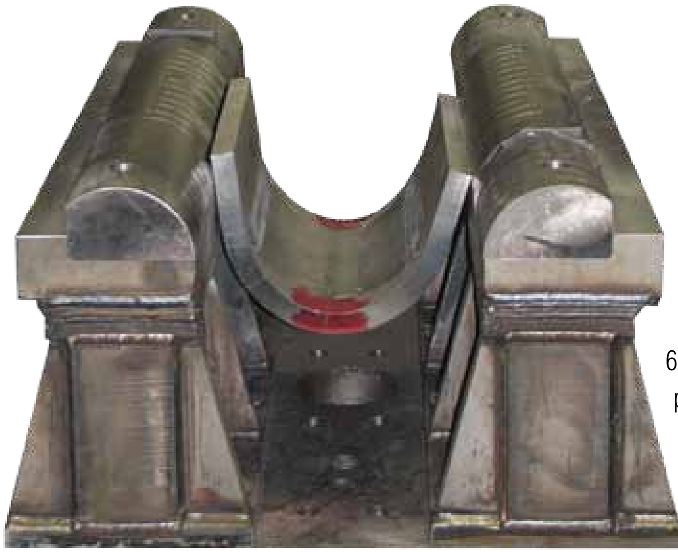
METALWORKING TECHNOLOGIES

As Secretary of the Navy Ray Mabus said in Congressional testimony in March of 2010, the Navy and Marine Corps remain the most formidable expeditionary fighting force in the world. Currently half the Navy fleet is at sea, fighting wars in the Middle East, protecting international commerce off Somalia, stemming the flow of illegal narcotics from South America into the U.S., and providing defense and humanitarian aid around the globe. Secretary Mabus went on to say that the Navy's shipbuilding program, which includes building an average of ten ships per year, is making the most cost-effective decisions to achieve the most capable force.

The Navy Metalworking Center (NMC) is leading efforts to increase affordability of Navy weapons systems with innovative and pragmatic metalworking solutions. NMC and its partners in government, ship systems, and industry work together to meet the Navy's current and emerging needs for a sustainable and superior force. This report highlights the center's most recent technical and implementation successes in metalworking and joining technologies, shipyard processes, advanced metallic materials, design for manufacturability, and coatings applications and removal. At the heart of much of NMC's work is improving metalworking technologies used in the construction of Navy weapons systems.

Littoral Combat Ship. Lockheed Martin photo

Alloy 625, a nickel-based alloy, is difficult to form, particularly at room temperature. A Navy Metalworking Center (NMC) project minimized potentially significant schedule delays for the construction of the CVN 78 aircraft carrier by identifying optimal forming practices for Alloy 625 in several critical components as well as by evaluating the corrosion performance of the Alloy 625-to-HSLA (high strength, low alloy) steel welds. Using the project findings, Northrop Grumman Shipbuilding-Newport News (NGSB-NN) was able to form several complex shapes on the first attempt and in sufficient time to support the production schedule for these critical components. The project results minimized the risk of cracking this very expensive material, which would not only delay the production schedule but would also add cost to re-manufacture these shapes. This project supports the efforts to attain the desired benefits of Alloy 625 and to achieve an extended life cycle for Navy ship seawater cooling system designs. NMC worked with an Integrated Project Team (IPT) consisting of NGSB-NN, Naval Surface Warfare Center Carderock Division (NSWCCD), and the Future Aircraft Carriers Program Office to progress this technology.



By identifying optimal forming practices for Alloy 625, an NMC project minimized schedule delays in the construction of CVN 78. CTC photo

Another Alloy 625 project involved forming issues specific to piping systems on Virginia Class Submarines (VCS). The cost to produce seamless Alloy 625 large-bore elbows is high due to expensive raw material and forming costs. This project demonstrated that a newly identified closed-die, cold forming technique can be economically and successfully applied to manufacture large-bore, seamless elbows made of Alloy 625. The new cold forming process results in minimal thinning of the wall in the heel of the elbow, thereby allowing the wall thickness in the starting pipe to be reduced, which equates to less raw material required for a ship set of fittings. Cost savings are based solely on the current market price for the raw material used to manufacture the Alloy 625 elbows; therefore, raw material cost savings can range from $150,000 to $660,000 per VCS hull over the course of the project. Final cost savingd for the CVN were calcuated at $200,000 per hull. The project has positioned the forming vendor to compete in the next multi-hull procurement by General Dynamics Electric Boat (GDEB), starting with SSN 792. NGSB-NN has already procured seamless Alloy 625 elbows formed via the identified process for the CVN 78 Class. In addition to the two shipyards, the IPT included NAVSEA, the VCS Program Office, and Nuflo, Inc. The new manufacturing process is applicable to new construction, overhaul, and repair and can be further extended to Alloy 625 piping systems on all Navy platforms.

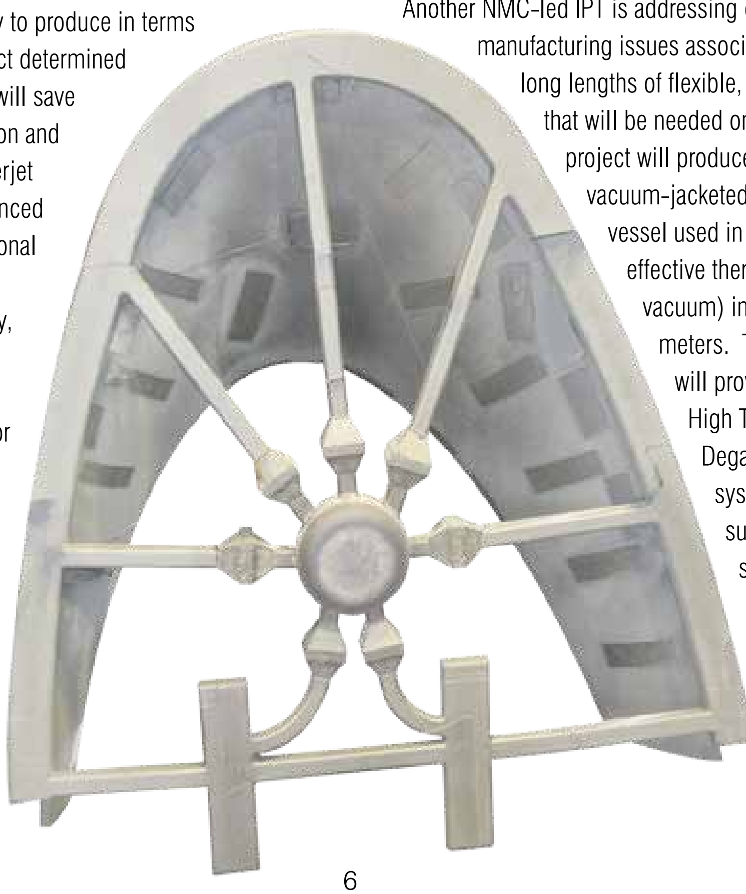
For the Lockheed Martin version of the Littoral Combat Ship (LCS-3), manufacturing of the waterjet inlet edges was the focus of another NMC project. The IPT developed a manufacturing solution that was implemented earlier than planned at Marinette Marine Corporation (MMC) in the summer of 2010 on LCS-3. The ship's

Northrop Grumman Shipbuilding has procured seamless Alloy 625 elbow piping for CVN 78 that was manufactured using a newly identified closed-die, cold forming technique that saves raw material costs. National Technical Systems photo

Clean steel casting practices developed by an NMC project team are lowering costs and shortening delivery time in VCS construction. Northrop Grumman Shipbuilding-Newport News photo

waterjet inlets have very particular geometry and smoothness requirements. Current shipbuilding practices available to LCS shipyards are not well suited to producing the inlet edge details. In addition, the inlet edges are costly to produce in terms of labor and schedule. This project determined that casting the tunnel inlet edge will save significant labor hours in fabrication and installation. A prototype cast waterjet inlet edge was created using advanced casting simulation, three-dimensional digital mold printing, and rapid casting prototyping. Subsequently, the design was incorporated into construction of the latest LCS ship. Based upon production labor hours required after successful implementation of the technology, more than 4,000 production hours have been saved using the castings developed by NMC. This project will also improve the yard's ability to produce multiple ships per year, as the current shipbuilding plan requires. The IPT included MMC, Bollinger, the LCS Program Office, Lockheed Martin Maritime Systems and Sensors (LM MS2), American Bureau of Shipping (ABS), and Gibbs & Cox.

Another NMC-led IPT is addressing cryostat configuration and manufacturing issues associated with fabricating the long lengths of flexible, vacuum-jacketed cryostats that will be needed on future Navy platforms. The project will produce the first U.S. manufactured vacuum-jacketed cryostats (a double-walled vessel used in conjunction with extremely effective thermal insulation with a high vacuum) in lengths of up to 100 meters. The long lengths of cryostats will provide necessary insulation on High Temperature Superconducting Degaussing (HTSDG) coil systems. Using a domestic supplier for the HTSDG cable systems will result in an

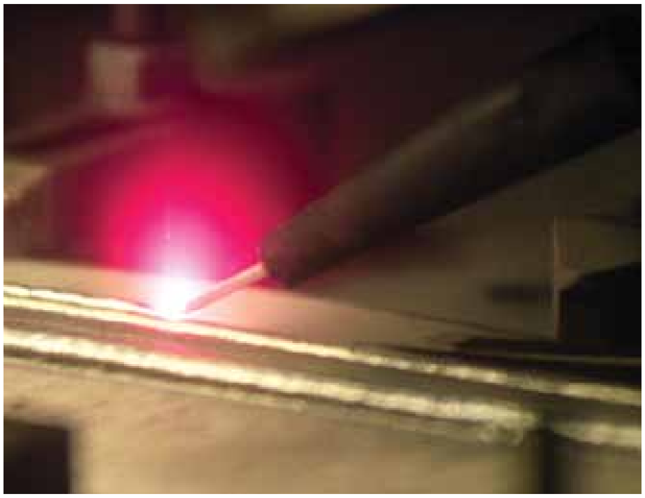


Marinette Marine Corporation is implementing a near-net-shape cast waterjet inlet edge on LCS that will reduce labor hours in fabrication and installation.

anticipated 30 percent cost savings, as well as diminished labor costs and installation duration due to a reduction in the number of cables to be pulled. This project is addressing cryostat configuration and manufacturing issues associated with fabricating the needed cryostats. Reliability performance, fabrication techniques, and the design life of the cryostat for naval platforms are also being evaluated. In addition to the cost savings, the HTSDG cable systems will reduce the overall degaussing system weight by an estimated 50 percent for most ship classes due to the reduced number of cables. The IPT for this effort includes Southwire, the company that will be modifying its production lines to manufacture these cryostats, NSWCCD, Oak Ridge National Laboratory, ASRC Aerospace, and NASA Kennedy Space Center. The project schedule supports procurement from Southwire early in 2012.

The foundry at NGSB-NN has already incorporated into standard operating procedures the results of an NMC-led project on steel casting. The project team, which also included NSWCCD and the VCS Program Office, evaluated current VCS high-strength casting problems, such as inclusions and entrapped gas. Using information gathered from production and baseline castings, the team determined the main causes of inclusions and then developed methods to reduce or eliminate the associated defects. Confirmation castings were prepared to demonstrate these clean steel practices. The objective of the project was to reduce casting cost and delivery time by improving the cleanliness of high-strength steel during melting and casting, thereby increasing casting quality, improving mechanical properties, and reducing rework. The identified clean steel practices are expected to lower costs by reducing rework and reheat treatments. This will result in an estimated annual savings in excess of $700,000 to the Navy. Casting delivery time will also be improved by an estimated seven weeks for large steel castings. Results from this project will also benefit several other Navy platforms.

NMC optimized laser peening process parameters for Naval weapons systems, which will benefit through reduced maintenance and replacement costs. Metal Improvement Company photo



NMC is investigating electron beam direct manufacturing to reduce repair and replacement costs on several Navy weapons systems. Sciaky photo

Briefly

In other projects addressing metalworking technologies, NMC developed recommended process improvements to produce high-quality Alloy 625 castings for CVN 79 aircraft carrier components. As a result of the project efforts, several components will be converted to forgings or weldments, while others will remain as castings.

Another current project will help the Navy better understand the effects of heat treatment on certain HY-80 castings, and ultimately save significant costs by better defining the potentially affected castings requiring inspection. The IPT is conducting experimental and computer simulations of the heat-treatment furnace conditions.

Innovative Electron Beam Direct Manufacturing is being investigated to reduce repair and replacement costs and cycle times for metallic components on several Navy weapon systems. With Direct Manufacturing (DM), component parts are produced on the basis of an electronic data set (CAD), eliminating the need for costly and time-consuming tooling.

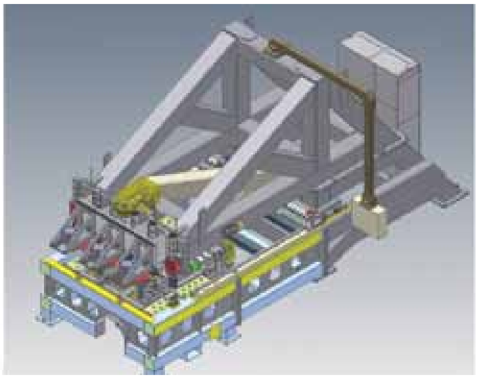
NMC evaluated the potential benefits of laser peening to improve the strength and extend the life of critical, highly stressed aircraft components in the Navy inventory. Laser peening is similar in concept to shot peening, but it imparts much higher and deeper residual compressive surface stresses with minimal plastic deformation. This project optimized the laser peening process parameters for the Goshawk Navy trainer arrestment hook shank (AHS) and the F-35C (Navy version of the Joint Strike Fighter) catapult launch bar through material evaluation, demonstration and validation tasks. Laser peening will be implemented on both components following successful completion of full scale qualification testing. The Navy will accrue benefits from laser peening through reduced maintenance and replacement costs and increased aircraft availability.

JOINING TECHNOLOGIES

How metals are joined is a key consideration in manufacturing since virtually all products are fabricated using joining processes that require the joint to be equal or superior to the base material. NMC is leading project teams to optimize several metal joining technologies for use in shipbuilding applications. For example, NMC and its team members are currently advancing friction stir welding (FSW), determining parameters for hybrid laser arc welding, producing an alternate flame brazing process, and evaluating exothermic welding. These innovations will lower the cost of Navy ships and improve the quality of ship components.

NMC is developing a prototype flame brazing system that will reduce labor and production costs for CVN and VCS. CTC photo

An NMC project team designed, built, and demonstrated at Concurrent Technologies Corporation a low-cost, transportable friction stir welding (LC FSW) system that will be transitioned to production use at a shipyard. FSW is a solid state joining technology that offers benefits over traditional welding for several materials. In operation, the LC FSW machine essentially serves as an aluminum panel line, forming stiffened panels from edge-welded extrusions. By limiting the design's functionality to the specific needs of extrusion welding, the machine is less costly and provides a quicker return on investment. The simplified machine design requires minimal site preparation and is sized for mobility among and within shipyards. The machine's simplified controls and operation also reduce the skill set and technical support required for the operator. The low capital cost and proven design will enable industry to readily scale-up for multi-ship construction. Currently, the machine is planned for delivery to the winning bidder of the LCS construction contract, which is pending award. The LCS Program Office has been provided the technical data to support the LCS bid package. The dual-use machine design is available through NMC or the Defense Technical Information Center (DTIC) for other programs or industries in need of flat, thin, stiffened aluminum panel production. The LCS Program Office, NAVSEA, ABS, LM MS2, BIW, MMC, Bollinger Shipyards, Advanced Joining Technologies, Friction Stir Link, and Nova Tech Engineering contributed on this project.



NMC is modifying its previously designed low-cost friction stir welding system to reduce costs and increase the quality of the Joint High Speed Vessel. Nova Tech Engineering photo

NMC leveraging its work with the LC FSW system described above for the Joint High Speed Vessel (JHSV), whose design incorporates the use of large integrally stiffened aluminum panels produced via FSW. If panels are produced by off-site FSW vendors, the size of the panels is limited due to shipping constraints. Assembling smaller panels using conventional welding methods is costly and frequently results in excessive distortion and other quality issues. This project is modifying NMC's previous system design for on-site application in JHSV construction. With input from Austal USA, ABS, Nova Tech Engineering and the JHSV Program Office, NMC is developing a detailed design for an extended capabilities LC FSW machine, optimizing processes and tooling for JHSV products, and assisting in startup and training of the new system at Austal. This project will enhance the producibility of lightweight aluminum structures on JHSV, which will lower the cost of the ships, improve welded joint quality, and reduce vessel weight because there is no filler metal added to the weld as with traditional welding processes. These structures will be produced with reduced weld distortion and weld defects, which decrease rework, schedule impacts, and acquisition costs. In addition, the technical developments could potentially be leveraged for application to other platforms with aluminum structures. NMC will help implement the machine in Austal's production operations for JHSV.

Another NMC project optimized a different metal joining process, hybrid laser arc welding (HLAW), to improve fabrication of HSLA-80 T-Beams on DDG 1000. T-Beam stiffeners are used extensively in ship construction for decks, bulkheads, shells, and other structural applications. As the need for weight and cost reduction grows, alternate production methods are being considered to improve beam quality, to weld thinner plate materials, and to minimize distortion and the cost and availability of beams for ship construction. This project determined optimum processing parameters for HLAW of HSLA-80 T-Beams that will reduce production and assembly costs, as well as improve T-Beam quality for DDG 1000. In addition, the improved beam quality provides better fit-up during shipyard construction, which reduces assembly costs. The higher travel speed and less distortion are expected to reduce T-beam fabrication costs by 45 percent and cut ship construction cost by about $650,000 per hull. ABS has approved the HLAW process developed in this project, and American Tank and Fabricating Company (AT&F), has installed the necessary equipment and is obtaining qualification to make HLAW HSLA-80 T-beams for DDG 1000. In addition to ABS and AT&F, the IPT included the DDG 1000 Program Office, NSWCCD, BIW, the Naval Research Laboratory, NGSB-NN/GC, and Applied Thermal Sciences (ATS). Other potential platforms that could benefit from this project include LCS, which uses a variety of thin section materials such as ASTM A710, a material very similar to HSLA-80.

NMC is developing new flame brazing technology for Navy ships to reduce labor and production costs. NGSB-NN currently uses a hand-held torch to manually flame braze fittings shipboard. This process is labor intensive because of the time required to reach melting temperature of the filler material. The process also causes occasional paint damage because it is difficult to control the flame and to negotiate the minimal clearances surrounding the fitting. The limited clearance also makes it difficult to achieve a uniform bond, which causes occasional pipe leaks. Paint damage and pipe leaks result in rework that further adds to the brazing costs. The goal of this project is to produce a prototype flame brazing system to address these problems for CVN 78 class aircraft carrier and VCS construction. The new flame brazing technology will use a programmable logic controller, mass flow controllers, and a burner cage to surround the fitting. Total cost savings are estimated at $1.9 million, which includes the construction of three CVN and six VCS hulls and $240,000 in the overhaul of six CVN hulls. The proposed solution may also benefit other platforms requiring flame brazing. NGSB-NN will use the prototype to generate brazing procedures and qualification samples and will test the samples and provide the procedures and results. The prototype will be implemented into the CVN construction process at NGSB-NN by fall of 2011. Lean Engineering and NSWCCD are also contributing to this effort.

An NMC project is developing exothermic welding and insulation processes for splicing power cables that is expected to reduce labor hours for installation, as well as preventive and corrective maintenance.
Erico Products photo

Exothermic welding is one method available for joining two or more electrical conductors, and while the Future Aircraft Carrier Program Office supports the use of exothermic welding for performing multi-cable, copper conductor splices for Navy shipboard power applications, the process is not yet approved for Navy shipboard applications. NMC is leading an effort to evaluate exothermic welding and insulation processes for Navy shipboard power applications as a means of reducing total ownership cost. Exothermic welding requires no external source of heat or current and is expected to reduce the number of labor hours required for installation. However, the effects of shipboard environmental conditions on weld quality are not fully understood, and Navy and shipbuilder experience with the process is very limited. This project is evaluating the proposed exothermic welding and insulation processes for splicing high-current applications on CVN 78 Class carriers, such as electric propulsion and pulse-energy systems. Shipboard installation and repair procedures will be developed and approved for use. Benefits include reduced risk to quality and schedule; increased system reliability and availability; and enhanced, repeatable, cost-effective installation and repair procedures. This project will potentially lead to a Fleet-wide process for splicing power cables, which is especially applicable to high-current applications, such as electric propulsion and pulse-energy systems. NGSB-NN will implement the NAVSEA-approved procedures in the spring of 2011 to support use on CVN 78 Class Carriers. NSWCCD, General Atomics, Erico Products, 3M Company, NAVSEA, NAVAIR, and NGSB-NN are providing technical contributions to this project.

SHIPYARD PROCESSES

Shipyards involved in the production of Navy ships are key partners in all NMC project teams. They know first-hand many of the issues and processes that need to be investigated, and they implement the results of successful NMC projects. Some recent NMC projects that have led to improved shipyard processes include the development of an automated track weld shaver system, which is significantly reducing costs for DDG 1000. That same system is being modified for other shipyard uses and will reduce manual labor and associated injury claims. Lost work days will also be minimized through the use of an NMC-developed environmental control system for painting operations. These and several other shipyard process improvements are summarized in this section.

Bath Iron Works is using a portable track weld shaver tool that automatically faces the weld reinforcement on DDG 51 and DDG 1000 exterior hulls, substantially reducing the amount of hand grinding and associated injury claims, labor costs, and production costs.
Bath Iron Works photo

An NMC project team developed and commercialized a portable tool that mechanically shaves weld reinforcement and is expected to reduce the cost of construction by $2.77 million for the DDG 1000 Program's three ships. DDG 1000 Class ships have a substantial requirement for hull surface fairness both above and below the waterline. Butt welding exterior ship hull and deck panels produces a weld protrusion that exceeds these fairness requirements. As a result, approximately 23,000 feet of weld reinforcement must be hand ground flush. Manual weld removal is slow, which increases shipbuilding costs, and the repetitive nature of hand grinding causes frequent injuries and costly medical expenses. This project developed a portable track weld shaver tool, which is now commercially available through PushCorp, Inc., that mechanically faces the weld reinforcement, substantially reducing the amount of hand grinding and associated injury claims, labor costs, and production costs. The tool's average reinforcement removal rate was verified to be well in excess of 40 feet per hour compared to the present rate of three feet per hour. The weld shaver tools have been implemented at General Dynamics Bath Iron Works (BIW) in the construction of DDG 51 and DDG 1000 and are awaiting implementation on the flight deck of a Landing Helicopter Assault (LHA) at Northrop Grumman Shipbuilding-Gulf Coast (NGSB-GC). The tool also will be used for the removal of lifting lugs on DDG 51 and up to 14,000 feet of weld protrusions on the LHA flight deck. GDEB and NSWCCD were also involved in this effort.

The weld shaver tool described above was modified and has been implemented for back gouging in the construction of DDG 1000, specifically for arc gouging and grinding the Peripheral Vertical Launch System and Anti-Propagation Wall. The current manual process is labor intensive, and the repetitive motion causes numerous injuries claims for injuries such as carpel tunnel syndrome. Adapting the track weld shaver, which has been successfully demonstrated at both BIW and NGSB-GC, will increase the DDG 1000 back gouging production rate by at least 150 percent and eliminate the labor currently required to clean and dress by grinding a deep arc gouged joint. As a result, BIW estimated a labor savings of approximately $400,000 per DDG 1000. The total cost savings for all DDG 1000 production is in excess of $1 million. In addition, if mechanized back gouging can be introduced at NGSB-GC for LHA, Landing Platform Deck (LPD), and National Security Cutter applications, an estimated savings of approximately $1.4 million may be realized. PushCorp, Inc., NSWCCD, NGSB-GC, and BIW are contributing to this project.

Implementation was achieved ahead of schedule of an NMC-developed environmental control system in VCS construction. Currently, VCS modules are built at one facility (General Dynamics Electric Boat-Quonset Point [GDEB-QP]) and shipped to another facility (General Dynamics Electric Boat-Groton or NGSB-NN) for

The track weld shaver system shown on the opposite page was modified to perform back gouging on DDG 1000, which will save $400,000 in labor per hull. Bath Iron Works photo

final assembly. Prior to shipping, the final paint system must be applied to various compartments. In order to apply the paint system, environmental conditions need to meet certain specifications. Because GDEB-QP lacks automated environmental controls for work spaces within the individual submarine modules, an average of 41.6 workdays are lost per year. An NMC project team developed a cost-efficient environmental control system for painting operations that will reduce lost work days. The IPT, including GDEB, VCS Program Office, and the NSWCCD, investigated the types of access required by trades, the various envelopes of workspaces that may be controlled, and the safety requirements for painting operations. Their work also involved identifying commercial technologies to meet requirements, selecting equipment, and conducting a cost benefit analysis for each potential solution. NMC recommended using insulated metal panels and fabric enclosures along with HVAC equipment to control the environment in major modules in

USS Missouri SSN 780 (VCS). U.S. Navy photo

order to minimize the lost work days associated with painting. While implementation was originally planned on SSN 785, partial implementation was expedited to support construction of SSN 782 during the summer of 2010. This partial implementation resulted in GDEB experiencing no lost work days related to insufficient environmental controls and supported on-time delivery of three major modules to the final assembly facility in Groton, Connecticut. Implementation also resulted in an increase in shipbuilder morale, as employees worked in an air conditioned environment. Recommendations from this project will be further implemented on future hulls to minimize lost work days associated with environmental conditions falling outside of the specification. The project will also lead to reduced heating costs by minimizing the need for portable heaters and allowing more efficient freeze protection.

NMC developed an improved process for attaching the deckhouse on the DDG 1000 class ships to the deck. DDG 1000 includes a non-metallic composite deckhouse that is bolted to steel plates that are welded to the deck. Welding of these plates could potentially overheat the composite material and cause significant damage. The previous procedure required this welding to be done in very short segments to avoid overheating, which would have been very time consuming and costly for the 20,000 feet of welding needed. NMC worked with NGSB-GC, NSWCCD, and the DDG 1000 Program Office to identify welding and cutting process parameters that would permit welding in long lengths without damaging the composite material. The new process saves approximately 4,700 labor hours and $280,000 per ship in the three-ship class. The key elements of these improvements are control of weld speed and a process to improve the accuracy of the cut. The project team also identified other supporting technologies to make the cutting process more accurate and to ensure the composite material is not damaged by stray sparks during cutting. Implementation occured at the Northrop Grumman Shipbuilding facility in Gulfport, Mississippi, when the deckhouse was attached to the deck in July 2010. The same process is also applicable to attachment of the LPD 17 Class Advanced Enclosed Mast System.

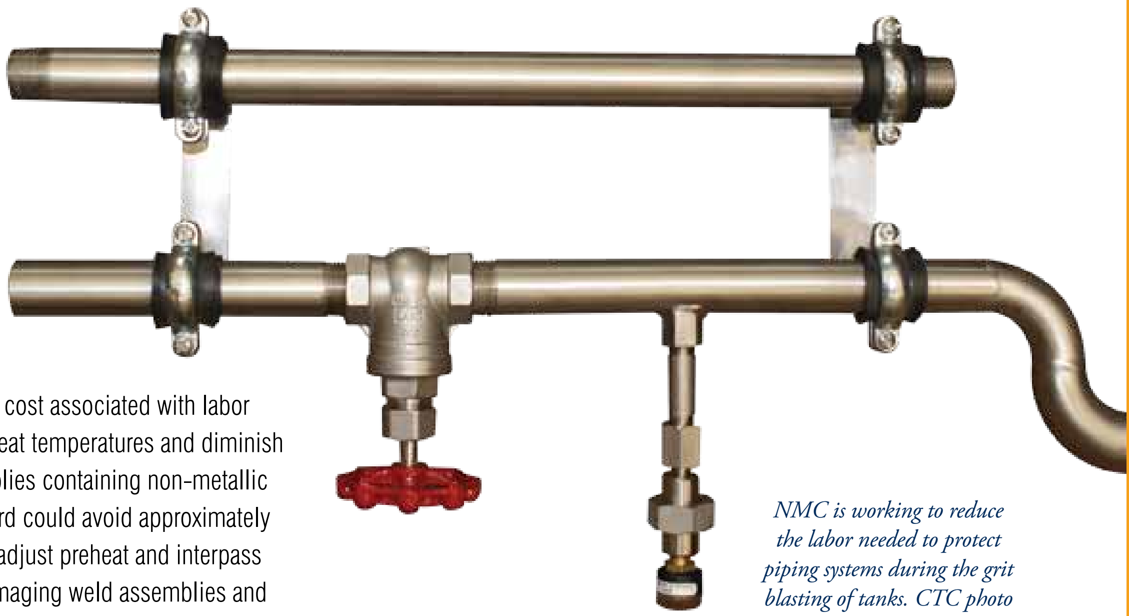
In another project aimed at reducing non-metallic material heat issues, NMC is leading an effort that will create a prototype remote welding preheat control system for use in CVN 79 construction at NGSB-NN. Preheating of welding assemblies is a common practice in shipbuilding. A minimum preheat temperature must

Improved welding and cutting processes to connect the DDG 1000 deckhouse to the deck will save more than $840,000 for the ship class. NGSB-GC photo be achieved to satisfy welding needs, but the upper limit may be bound by the temperature sensitivity of non-metallic materials that are packaged inside the welding assembly in certain applications. Currently, an operator monitors the temperatures by using "temp sticks" and manually controls the temperatures by plugging/ unplugging heater bars or using percentage timers. This process can be labor intensive. Also, with this system the assembly is susceptible to overheating, causing damage to the non-metallic material. Rework associated with cleaning and re-applying non-metallic material and addressing damaged weld assemblies causes significant additional cost and schedule delays. A prototype remote welding preheat control system, being developed through the combined efforts of the Future Aircraft Carrier Program Office, NSWCCD, NGSB-NN and GDEB, will demonstrate the capability to control the preheating process in a production environment. The prototype system will have the capability to be modified and expanded for production use. The remote welding preheat control system will reduce cost associated with labor related to controlling welding preheat temperatures and diminish the risk of damage to weld assemblies containing non-metallic materials. Specifically, the shipyard could avoid approximately $800,000 per hull to monitor and adjust preheat and interpass temperatures. Also, the risk of damaging weld assemblies and the resulting cost and schedule impacts would be reduced. After implementation, the system would support other Navy weapon system applications involving less heat-sensitive, but manually time-consuming processes for pre-heated metals.

Briefly

NMC is developing solutions to prevent coating damage associated with small welds made late in the carrier construction cycle after coating and outfitting have taken place. The temperature extremes during welding can damage the coating on the opposite side of the structure being welded, which creates additional surface rework for coating repairs. The recommended changes developed within this project can potentially reduce rework labor by 9,000 hours per ship and will be implementable at NGSB-NN during outfitting of CVN 78 in the third quarter of FY12.

NMC is leading a project aimed at reducing labor in VCS construction by improving the process for blasting tanks. Currently, piping systems are wrapped to prevent them from being damaged when the hull is grit blasted. After grit blasting, the piping is unwrapped and blown down to remove grit. The project team, including GDEB, NGSB-NN, the VCS Program Office, and NSWCCD, will optimize the blasting parameters to improve grit blasting efficiency and will determine if the amount of piping to be wrapped can be reduced. Less labor-intensive methods of wrapping the piping will also be developed. The results of this project are expected to save approximately $290,000 per hull in reduced labor, materials, and disposal cost. Initial implementation is expected to take place at GDEB and NGSB-NN for SSN 787 in 2012. Project results will also apply to almost all ship classes.



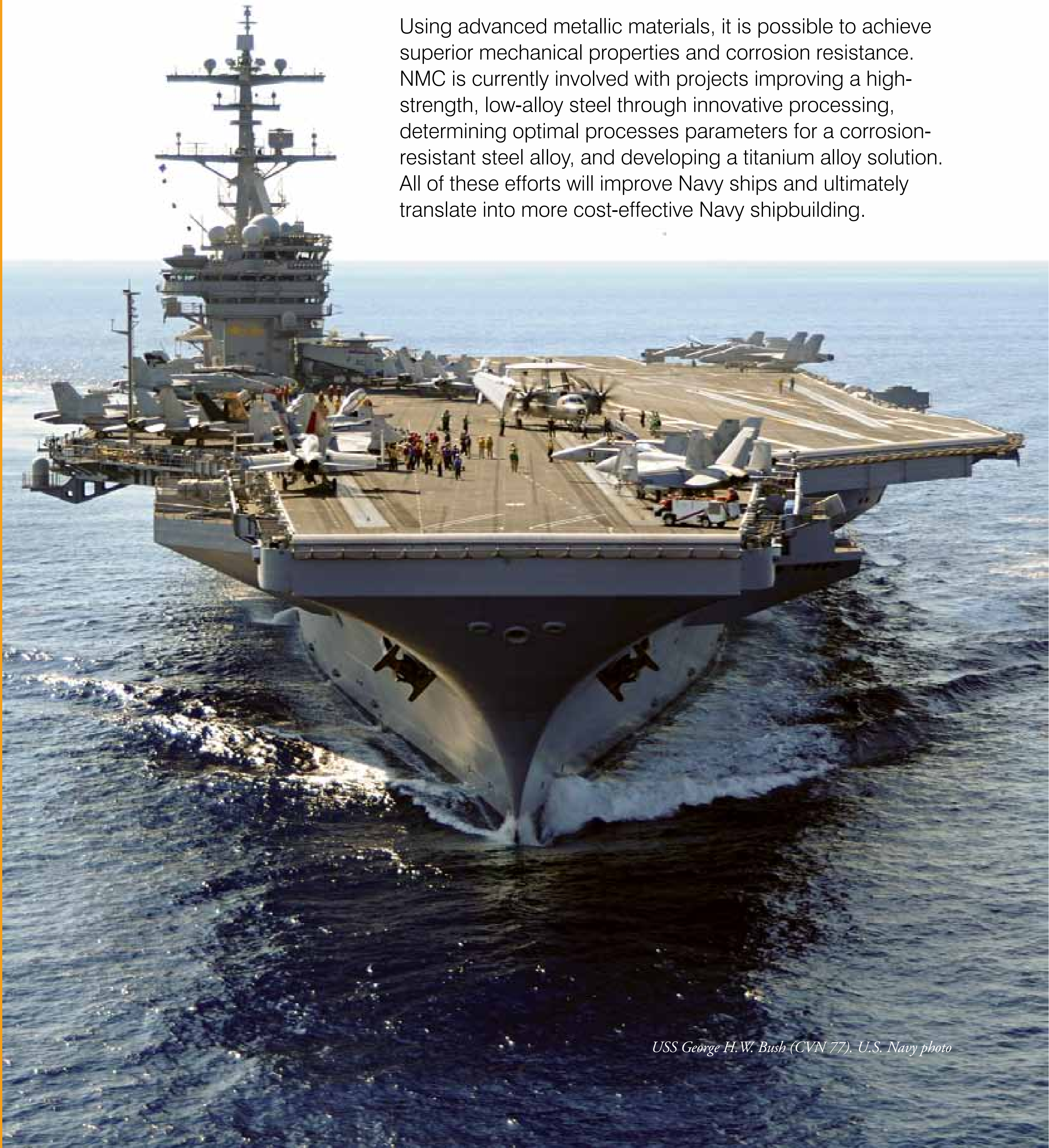
NMC is working to reduce the labor needed to protect piping systems during the grit blasting of tanks. CTC photo

BIW is modifying and evaluating changes to its handling of HSLA-80 steel plates as a result of an NMC project that investigated distortion issues with the plates to be used in the construction of DDG 1000. The IPT, which includes DDG 1000 Program Office, BIW, Arcelor Mittal Coatesville Plant, and PD Technologies, identified potential root causes of the distortion and recommended procurement specifications needed for future plate sourcing. BIW has since modified a cutting machine specification and ordered a new cutting system that will significantly reduce the heat input into cut parts. BIW is also evaluating changes to part layout (nesting), cutting sequence, cutting parameters and the use of retention tabs, all of which have been defined in this project. BIW anticipates cost avoidance in production due to reduced labor needed to meet fit and fairness requirements and by reducing the need for post-burning flattening.

NMC is also working on a project that will reduce labor hours in shipyard processes involving large diameter pipes on VCS. (See page 17 for details.)

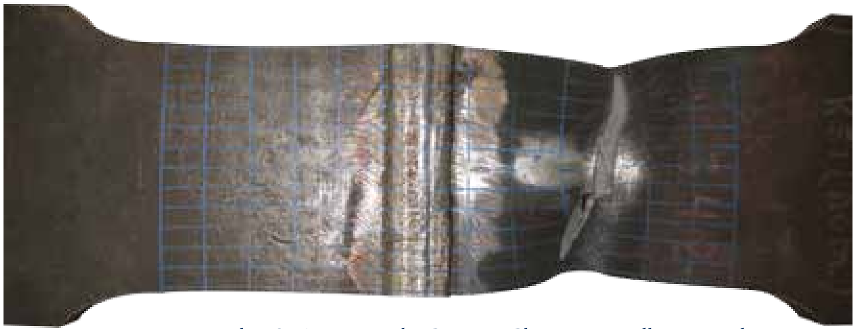
ADVANCED METALLIC MATERIALS

Using advanced metallic materials, it is possible to achieve superior mechanical properties and corrosion resistance. NMC is currently involved with projects improving a high-strength, low-alloy steel through innovative processing, determining optimal processes parameters for a corrosion-resistant steel alloy, and developing a titanium alloy solution. All of these efforts will improve Navy ships and ultimately translate into more cost-effective Navy shipbuilding.



USS George H.W. Bush (CVN 77). U.S. Navy photo

In an effort to reduce weight and lower the center of gravity on the CVN 78 Class of aircraft carriers, an NMC project increased the performance and strength of HSLA-100 (high-strength, low alloy) steel through innovative thermo-mechanical processing and heat treatment. These improvements enabled NGSB-NN to use this new HSLA-115 (115 ksi yield strength) steel at reduced thicknesses compared to the baseline material. HSLA-115 will reduce weight, while meeting all performance requirements for a critical structure application. Additional objectives were to evaluate HSLA-115 for a large-scale production plate application; to validate HSLA-115's performance and manufacturability; and to achieve welding and shipyard practice optimization and vendor qualification. Implementation of HSLA-115 on the CVN 78 Class has netted 132 long tons of topside weight savings per hull and achieved a 0.05-ft KG recovery. In addition, NGSB-NN demonstrated acceptable forming and welded tie-down behavior with HSLA-115. While the HSLA-115 steel cost is slightly higher than HSLA-100, the weld volumes will decrease ten percent due to thickness decrease. Additional applications may be considered in future weapon system designs. The Future Aircraft Carrier Program Office has approved the use of HSLA-115 in the CVN 78 Class baseline design, and HSLA-115 has been incorporated into the ship specifications and the fabrication document. Implementation of HSLA-115 on the CVN 78 Class was achieved ahead of schedule due to the combined efforts of the IPT. This two-phase project involved the contributions of the Future Aircraft Carrier Program Office, NSWCCD, Navy Joining Center (NJC), NGSB-NN, ArcelorMittal Steel USA, and DDL Omni.



Using a new steel, HSLA-115, on the CVN 78 Class carrier will save 132 long tons of topside weight and improve performance on the CVN 78 Class carrier. CTC photo

NMC is optimizing processing parameters for 15-5PH steel to replace Monel® K-500 in key components of U.S. submarines, which will save approximately $9.4 million over the remaining life of 70 hulls. CTC photo

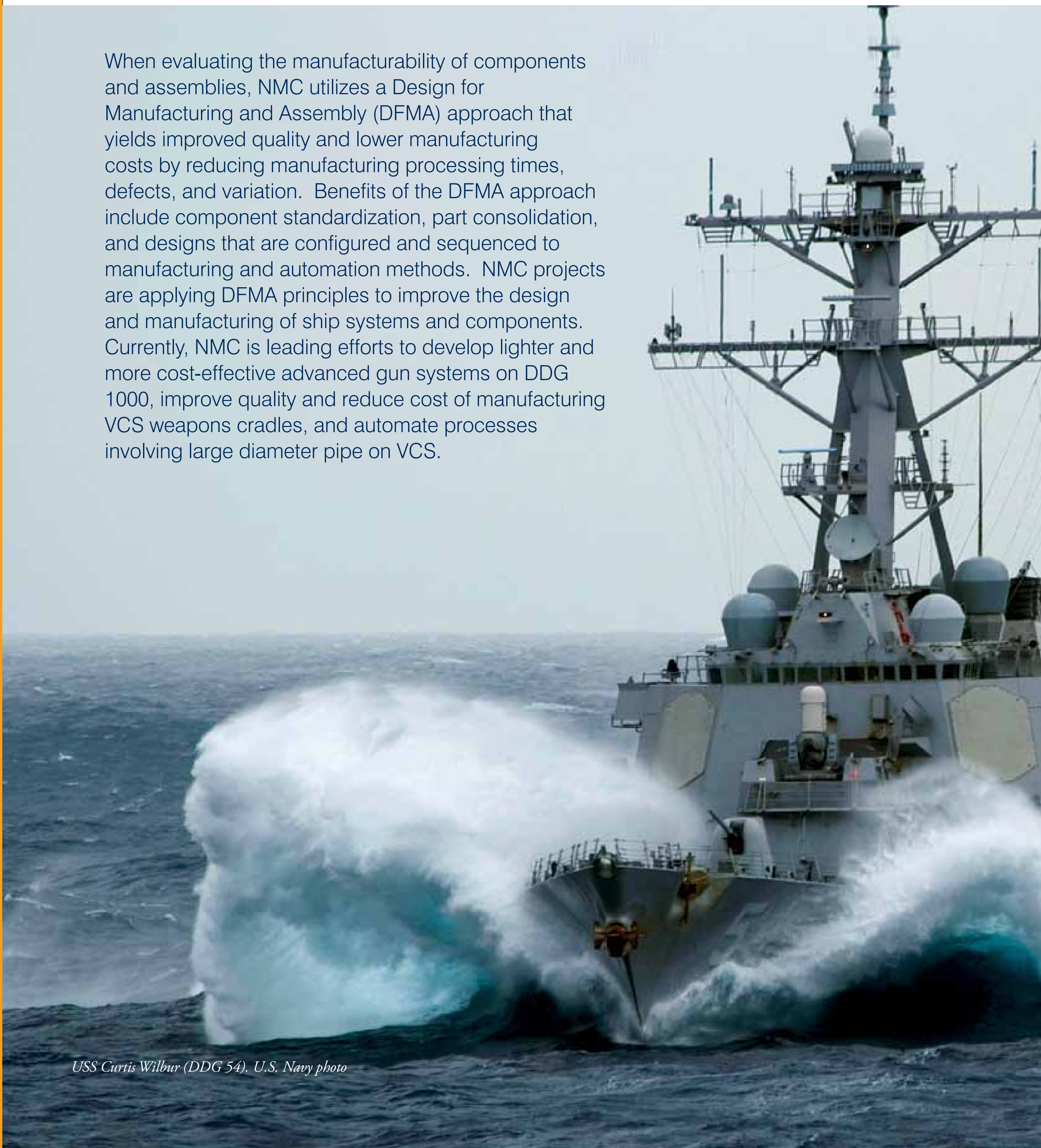
NMC is determining optimal processing parameters for a corrosion-resistant steel alloy in an effort to optimize the mechanical properties of this material for use in several critical components in Navy submarines. The torpedo tube muzzle door operating linkage for the Los Angeles (SSN 688) and subsequent classes of Navy submarines include several components produced from K-Monel® (Ni-Cu-Al) forgings. The components have shown a propensity for hydrogen embrittlement and stress corrosion cracking in a seawater environment and must be replaced after eight years of service. This project seeks to replace the K-Monel forgings with modified 15-5PH steel forgings, which provide improved mechanical properties and corrosion resistance, negating the need to replace components during the submarine's lifetime. By eliminating the need to periodically replace these critical components in the in-service fleet, the Navy has estimated the cost savings to be approximately $9.4 million over the remaining life of these 70 hulls. In addition, a 55 to 60 percent material cost savings is projected in the construction of these components for VCS. Upon successful completion of the project, the implementation of the 15-5PH linkage components will begin in VCS new construction, starting in FY12. In addition, retrofit of existing K-Monel linkage components on the Los Angeles, Ohio, and Seawolf Classes of submarines will begin within two to three years, pending successful sea trials. The IPT for this project includes the Program Offices for Strategic and Attack Submarines and VCS, Naval Undersea Warfare Center-Newport (NUWC-Newport), NSWCCD, and GDEB.

An NMC project team is developing a potential titanium alloy solution for the LCS gas turbine exhaust uptakes that could significantly reduce weight on LCS. In addition to reducing weight, titanium's superior corrosion resistance can potentially reduce life-cycle costs. The project will address advanced welding technologies and the use of net shapes to reduce cost. NMC will work with Industry teams and shipyards, Gibbs & Cox and a titanium fabricator, with oversight from NAVSEA and ABS, to down select the appropriate titanium alloys, build a prototype section and deliver a section for testing.

NMC identified optimal forming practices and evaluated corrosion performance of Alloy 625 in a project aimed at reducing schedule delays for CVN 78. (See page 5 for details.)

DESIGN FOR MANUFACTURABILITY

When evaluating the manufacturability of components and assemblies, NMC utilizes a Design for Manufacturing and Assembly (DFMA) approach that yields improved quality and lower manufacturing costs by reducing manufacturing processing times, defects, and variation. Benefits of the DFMA approach include component standardization, part consolidation, and designs that are configured and sequenced to manufacturing and automation methods. NMC projects are applying DFMA principles to improve the design and manufacturing of ship systems and components. Currently, NMC is leading efforts to develop lighter and more cost-effective advanced gun systems on DDG 1000, improve quality and reduce cost of manufacturing VCS weapons cradles, and automate processes involving large diameter pipe on VCS.



USS Curtis Wilbur (DDG 54). U.S. Navy photo

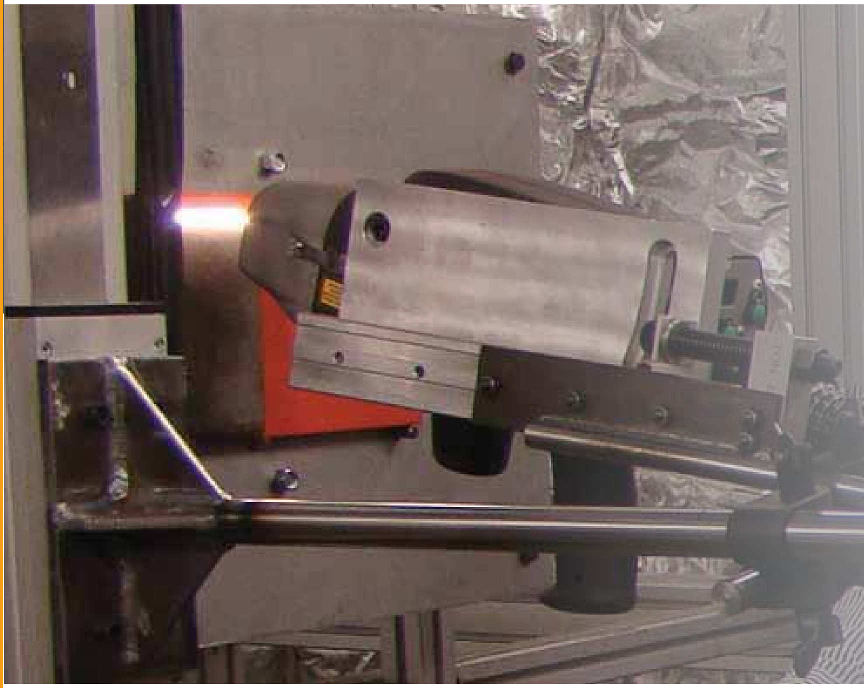
NMC developed new manufacturing approaches that will reduce manufacturing cost and system weight of DDG 1000's Advanced Gun System (AGS). DDG 1000 will be equipped with two AGSs, which are used to package, handle, store, and transport the Long-Range Attack Projectile munitions and charges through the logistic channels and within the AGS magazine in the DDG 1000 hull. The primary objective of the project was to reduce manufacturing cost of the AGS pallet assembly by 10 percent without compromising system performance, with a secondary objective of reducing system weight by the same ten percent margin. A ten percent reduction in manufacturing cost will provide a $5.3 million per hull savings and a reduction in system weight that will improve handling, safety and survivability functions of the AGS pallet system. NMC optimized the manufacturing approaches developed during the first phase of this project, utilizing friction stir welding for the AGS pallet structure side panels to control overall distortion with advanced machining and casting techniques to produce a prototype AGS pallet system. That pallet system was evaluated by the IPT, which includes BAE Systems, Naval Surface Warfare Center Dahlgren and Port Hueneme Divisions, and Integrated Warfare Systems' Naval Guns Program Office (PEO IWS 3C). A Technical Data Package of demonstrated manufacturing improvements and cost reductions was delivered to BAE Systems and PEO IWS 3C for implementation into the Low-Rate Initial Production builds of the AGS Pallet System early in 2011.

NMC optimized manufacturing approaches used for the Advanced Gun System pallet in DDG 1000, resulting in $5.3 million manufacturing cost savings per hull, as well as a weight reduction that will improve safety and survivability. CTC photo

VCS weapons cradles, which are complex assemblies manufactured to very tight tolerances, are the focus of another DFM project. This project will reduce weapons cradle manufacturing costs by improving the manufacturability of the cradle and/or components. Lean Manufacturing and DFM principles will be used to identify areas to reduce manufacturing costs and improve accuracy, consistency, lead times, and quality. For 26 VCS hulls, the savings are estimated to be $17 million from reduced rework and improved DFM and assembly recommendations. Higher throughput will result in the ability to support the two VCS hulls per year construction schedule. The IPT, including the VCS Program Office, NUWC-Newport, GDEB, NGSB-NN, Boothroyd-Dewhurst, and W Industries, will validate project recommendations and incorporate them into engineering change notices, business case assessments, and production drawing revisions. Low-risk, high-benefit improvements will be implemented as soon as possible based on manufacturing and production cycles. The overall results of the project will be implemented at GDEB and NGSB-NN on SSN 788 in February 2013.

In another project addressing VCS manufacturing challenges, NMC is leading an effort to improve processes involving welding methods for large diameter pipe details. Current VCS designs contains off-hull new construction pipe welding details that involve various complex configurations for large diameter pipe (3"-12") for preparation, fixturing, positioning, fit-up, and welding methods. The current fabrication techniques and weld processes require excessive labor in set-up and handling times, reducing work cell process flow output and efficiencies. This project will investigate the improvement of certain areas of pipe preparation including fixturing, positioning, and fitting; automation of pipe boss methods; enhanced welding automation; and the use of internal pipe joint blending tools and applications to reduce pipe section cutting, rework, and pipe material scrap. Projected savings are 8,500 labor hours per ship reduction in manual labor, which equates to approximately $510,000 per hull savings and a projected $13.7 million savings over the remaining VCS builds. Prototype process improvements will be tested and validated in both GBEB and NGSB-NN pipe shops in FY2011. Implementation is expected in both VCS pipe shops for SSN 788 hull early in 2012. GDEB and NGSB-NN are joined on the IPT by NSWCCD and the VCS Program Office.

COATINGS APPLICATION AND REMOVAL



An important factor in the construction of naval vessels is the coating placed on metal hulls and components. Determining what surface treatment is used and how it is applied and removed can have a large impact on the weapon system's performance, life cycle, and cost. NMC work in this area involves hull treatment systems, laser coating removal, temporary coatings used during the shipbuilding process, and damping tile.1000, improve quality and reduce cost of manufacturing VCS weapons cradles, and automate processes involving large diameter pipe on VCS.

An NMC project team evaluated various improvements to the Surface Ship Hull Treatment (SSHT) systems for DDG 1000 in an effort that will reduce per-hull costs by $3.5 million. Delivery requirements for DDG 1000 necessitate the application of a HT system to portions of the underwater hull and waterline area. The objective of this project, whose IPT included NSWCCD, NJC, NGSB-GC, and BIW, was to reduce the cost for procurement, installation, repair, and decommissioning of hull treatment on DDG 1000. The project assessed alternative anti-corrosive paints and adhesives, efficient manufacturing methods of system components, removal of lead from the system, materials/processes to improve installation, and identification/verification of a means to improve the system's durability. The cost savings total includes a procurement cost reduction of approximately $800,000 per hull; an overall reduction in installation cost of more than $1.6 million per hull; a repair cost reduction of nearly $700,000 per hull; and decommissioning cost reduction of $350,000 per hull. The project recommendations are expected to be incorporated into the hull treatment design and corresponding installation process instruction.

NMC is evaluating and developing laser coating removal processes in two current projects to reduce costs and labor over more traditional methods of coating removal. Pictured are Gerred Price, mechanical engineer, and Greg Woods, NMC program officer. CTC photos

Another NMC coatings project evaluated laser ablation paint removal on naval ships during in-service inspection, maintenance, and repair. Current methods of paint removal are either slow and labor intensive with poor ergonomics or material intensive with substantial amounts of secondary waste that add tremendous expense and environmental impact. Laser ablation was investigated because it does not consume materials, generates no secondary waste, has low operating costs, and is operator safe and friendly. In addition, recent advancements have improved removal rates and efficiency. The IPT, including the Aircraft Carrier Maintenance Program, NGSB-NN, and NGSB-GC, evaluated commercially available, self-contained, hand-held laser cleaning and paint removal equipment for shipboard interior paint removal applications on Nimitz (CVN 68) Class Aircraft Carriers. Four in-service maintenance applications that could benefit the most from laser ablation paint removal were identified. After optimizing the laser ablation parameters for the applicable paint systems, laser ablation removal rates were significantly faster than the labor-intensive baseline processes in most cases. In addition, laser ablation eliminated the material, clean up, and disposal costs associated with the material-intensive processes. The results of this project will be incorporated into the CVN 68 Class carrier maintenance procedures as an alternate surface preparation method and will be implemented at NGSB-NN and Norfolk Naval Shipyard in early 2012. Implementation of laser ablation paint removal may also offer benefits for other weapons platforms such as VCS and other phases in the life cycle of naval ships including new construction, ship breaking.

Laser coating removal is also being considered in an NMC project working to improve submarine propulsion shaft refurbishment. The goal is to eliminate the extensive time and costs associated with moving submarine propulsion shafts within repair shipyards by replacing grit blasting with operations that can be performed in the machine shops. NMC is working with Portsmouth Naval Shipyard, as well as consulting with Navy shipyards Norfolk, Pearl Harbor, and Puget Sound, to develop laser processes to remove coatings. Various laser systems will be evaluated, and parameters will be developed and optimized for shaft refurbishment. The final solution will be integrated with existing propulsion shaft lathes and roller stands. This project is expected to save up to $360,000 per shaft and reduce refurbishment duration by up to ten weeks. Implementation is planned in March of 2013 at Portsmouth Naval Shipyard.

NMC developed improvements in various aspects of surface ship hull treatment systems on DDG 1000, which will reduce the cost for procurement, installation, repair, and decommissioning. NMC photo.

Briefly

An NMC project team is identifying temporary coatings that will prevent or decrease damage and corrosion that occurs during the shipbuilding process, significantly reducing the labor currently needed to repair the damage and remove corrosion. The project team, including the Future Aircraft Carriers Program Office, NSWCCD, NGSB-NN, and NGSB-GC, will investigate, modify, and demonstrate temporary coatings/materials that can be easily applied and stripped. Implementation is expected to occur on some CVN 79 modules; future DDG 51 Class vessels, DDG 113 and DDG 114; and LHA 6.

Two projects already mentioned in this annual report also are advancing coating processes for Navy shipbuilding. In one, an NMC project team developed an environmental control system for painting operations that will reduce lost work days in the construction of VCS. (See page 11 for details.)

The other previously mentioned project is aimed at reducing labor in VCS construction by improving the process for blasting tanks. (See page 13 for details.)

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