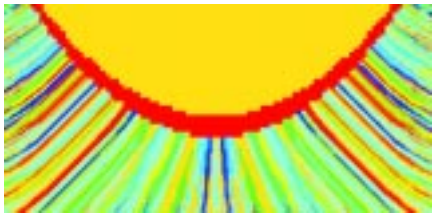
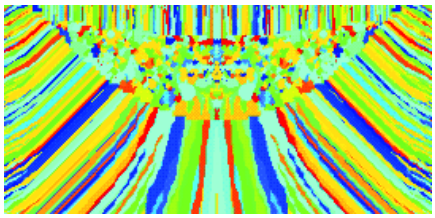
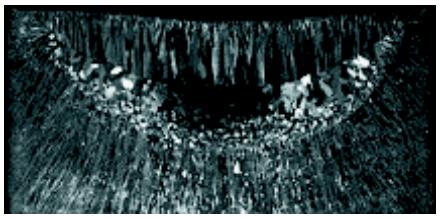
METALWORKING TECHNOLOGY
UPDATE
Spring 2001

NCEMT Helps the AAAV to Meet its Mission Requirements

Combined mission requirements for the U.S. Marines' Advanced Amphibious Assault Vehicle (AAAV) include high survivability, mobility, lethality and reliability, while minimizing weight. To meet these requirements, a high-strength aluminum armor plate (2519-T87) was selected for the structure. The NCEMT successfully developed an improved fabrication technology and corrosion protection for aluminum alloy 2519, as well as data on its mechanical properties and corrosion resistance. Prior to this work, aluminum alloy 2519 had never been successfully extruded; however, the NCEMT orchestrated the fabrication of AAAV-specific extrusions and established a production path with near-optimum extrusion parameters. The NCEMT also successfully demonstrated the open-die multi-axis forging of 2519 that effectively broke down the cast structure, allowing for high properties in the final hand forging, including good strength-ductility combinations. The first hot working simulation data for 2519 was generated through the NCEMT. This information can now be used to select optimum rolling, extrusion and forging parameters. The selected extrusion and forging parameters produced crack-free parts with good dimensional tolerance.

Friction Stir Welding (FSW) parameters for 2519 were developed by the NCEMT, producing welds with significantly higher strength and ductility than conventional fusion welds. The mean tensile strength of 50 ksi with 11-percent elongation (2-in. gage) is clearly superior to the 43 ksi and 5–6-percent elongation reported in the literature for optimized gas metal arc weldments. The NCEMT also fabricated 2519 FSW butt welds that passed the demanding Fragment-Simulating Projectile (FSP) ballistic test for the very first time. In addition, promising surface treatments that reduce the corrosion rate of 2519 have been identified and evaluated.

The NCEMT is continuing its efforts to build upon this technical foundation in the areas of extrusion, FSW, corrosion protection and component manufacturability to meet additional AAAV needs. The NCEMT is working directly with the AAAV prime contractor—General Dynamics Corporation—and the AAAV Program Office to ensure the successful implementation of this technology into the AAAV EMD phase, scheduled to begin in July. ■

NCEMT Identifies Lightweight Magnesium Alloy WE43A-T6 for AAAV Components

After extensive evaluation of Department of Defense (DoD) and aerospace industry practices, the NCEMT has identified a lightweight magnesium alloy and assembly procedure for power transfer modules (PTMs) and transmission housings for the Advanced Amphibious Assault Vehicle (AAAV).

The AAAV currently relies on a sand-cast aluminum alloy for these components. Substitution of cast magnesium alloys could save considerable weight. However, magnesium alloys are anodic relative to most metals, especially other structural alloys in the AAAV, so, galvanic corrosion of sand-cast magnesium alloys assembled to other materials is a concern.

The NCEMT has identified sand-cast magnesium alloy WE43A-T6 as a promising alternative to aluminum alloy, along with an appropriate fastener system, sealant compound and coating system. To address AAAV field maintenance needs, a Brush-Tagnite coating repair procedure for magnesium alloy was evaluated and found to be effective.

As a result, satisfactory corrosion resistance was obtained in all aluminum-on-magnesium test assemblies. The WE43A-T6 alloy scratch test coupons treated with the Brush-Tagnite repair procedure did not show evidence of corrosion after three weeks of exposure. ■

RMI Titanium and Carpenter Technology Corporation Rely on NCEMT Melting and Casting Process Models

Hard-alpha and high-density inclusions are a confirmed source of failure for titanium-alloy jet engine rotating components. Current melting procedures cannot cost effectively reduce the probability of occurrence for these defects, which leads to safety concerns for all critical rotating components. The NCEMT developed a modeling tool for the plasma arc cold hearth melting (PAM) process, which has been implemented at Allvac, with specific emphasis on best practice and cost reduction in the manufacture of materials for F404 and F414 engine components for the Navy F/A-18 aircraft. This work was an extension of the successful work GE Aircraft Engines (GEAE) performed in a previous Air Force ManTech project on hearth-melt-only processes such as PAM.

The NCEMT developed and integrated three models (plasma torch, refining hearth and ingot solidification) into a modeling tool for the PAM process within the commercial COMPutational Analysis of Convective Transport (COMPACT™) code. This tool is capable of calculating refining efficiency and solidification macrosegregation. Three subscale and two full-scale unseeded melting experiments were conducted for model validation.

Based on the success of this effort, industry is funding the adaptation of

NCEMT process models to define best practices. For example, to optimize a new PAM furnace installed by RMI Titanium Company, model-based melting and casting experiments were performed to determine the best combinations of key process parameters such as torch power and hearth geometry.

Similarly, Carpenter Technology Corporation (CarTech) has tapped into the NCEMT results to model ingot solidification structure in vacuum arc remelting and other melt refining processes. These model-based experiments demonstrated the effect of process conditions, such as melt rate and power interruption, on the quality of the solidified ingot. In addition, to implement this process modeling tool into its production operation, CarTech is also initiating efforts to optimize homogenization and forging processes based on other NCEMT work. ■

COMPACT is a trademark of Innovative Research, Inc., Plymouth, MN

Powder Metallurgy Allows Weight Reduction for DoD Vehicles

The NCEMT knowledge base in the area of powder metallurgy (P/M) contributed significantly to an investigation of P/M use in DoD vehicles. Like all end users, the DoD is facing economic and regulatory pressure and is looking for methods to reduce the maintenance and fuel costs associated with its cars, trucks and tanks. At the same time, it requires its vehicles to perform well, and under harsh conditions. The ideal? Lightweight, high-performing vehicles. With its potential to reduce waste, improve manufacturing efficiency and reduce manufacturing costs, P/M provides the DoD with an attractive alternative to other parts-making methods. To efficiently tap these advantages, the DoD recognized that it first must identify the state-of-the-art for P/M before designing and procuring new components.

Photo: Metal Powder Industries Federation (MPIF), Princeton, NJ

The National Defense Center for Environmental Excellence (NDCEE), operated by Concurrent Technologies Corporation (*CTC*), was tasked by the DoD to conduct an investigation to identify the process, performance and cost advantages of using P/M components for automotive, diesel and light truck, and to identify candidate automotive components that could be made from metal powders. This investigation included extensive literature and Internet searches as well as a survey of the P/M community to ascertain the state-of-the-art of P/M processing. This lays the foundation to identify and assess potential P/M applications specific to DoD. The NCEMT was able to leverage its expertise by providing the NDCEE with valuable information already compiled from its extensive work in the area of P/M. The NDCEE was also assisted by General Motors (GM) Research and Development Center as a cost-share partner. The commercial vehicle industry also stands to benefit from the results of this survey.

In addition to per-component savings, three considerations were emphasized in collecting and analyzing information relevant for vehicular use: 1) reduce weight, 2) increase use of lightweight materials and 3) eliminate lead. For the first two considerations, weight reduction can be achieved either by using P/M parts that are not fully densified (e.g., contain residual porosity) or by replacing ferrous-based alloys with lighter weight alloys. Innovative techniques, such as cold-rolling and selective densification, have been developed to extend the useful range of application for less-than-fully-dense P/M parts. Aluminum alloys, which are significantly lighter than ferrous alloys, are already being used commercially in vehicles, and continuing research and development promises to quickly broaden the applications of these materials. Titanium shows promise, but is still limited by its higher material and processing costs. Alternatives are being developed to replace lead as an infiltrant for lubrication and as an additive to improve machinability because of the environmental and health concerns associated with lead. Although commercial applications are in their infancy, the continuing successes in research indicate that use of lead substitutes will grow.

As this investigation confirmed, P/M is a viable, mature processing technology that can meet user needs when applied according to good design practices for parts production. P/M has proven itself as a lower cost route to parts production, on a per unit basis, than many competing processes. ■

Photo: Metal Powder Industries Federation (MPIF), Princeton, NJ

Program News

Our long-time readers will immediately be aware of the style change for this new issue of the quarterly *Metalworking Technology Update*. We've deliberately chosen a news-focused format to replace the previous technically focused one. We believe this change will allow us to provide more up-to-date news about the NCEMT and metalworking, still showcasing groundbreaking technical work. This change is, in effect, a celebration. On September 1, 2000, *CTC* was competitively awarded a new five-year contract to continue the NCEMT's operation. We're pleased that the Office of Naval Research (ONR) saw in our proposal, and our prior performance, the evidence that we have, and will continue to, help ONR meet Navy System Commands needs. We thank those in industry who pledged their support to our continued operation, and those in the Navy community and industrial base who provided us with challenges and opportunities to make the NCEMT a success. In the transition from the "old" to the "new" NCEMT contract, we were fortunate to have full support from ONR in maintaining the continuity of ongoing projects. We're presently busy at work on ten MANTECH projects, three rapid response efforts and two development efforts funded by the Army. Soon we will initiate work on seven new projects addressing specific Navy needs. We're happy to be moving forward into the new millennium with ONR MANTECH as our sponsor. Come join us in working to meet Navy needs. ■

Calendar of Events

Shipbuilding Technologies 2001: A Shipbuilding Technologies Information Exchange

September 5–6
Beau Rivage Resort & Casino
Biloxi, Mississippi

Vice Adm. George P. Nanos, Commander, NAVSEA, speaking at a previous Modern Shipbuilding Technologies Demonstrations and Information Exchange.

This event is facilitated by the NCEMT and sponsored by the National Shipbuilding Research Program–Advanced Shipbuilding Enterprise, and ONR MANTECH. Keynote presentations will be given by NAVSEA, ONR, and the National Shipbuilding Research Program Executive Control Board. A panel discussion between the Navy and shipbuilding industry will focus on developing advanced technologies. Technical presentations will cover materials and tools for the shipbuilding community.

Presentations are being solicited for Materials & Standards, Production Processes, and Business Process technical tracks. Contact Tricia Wright at 814-269-2567 or wright@ctc.com. For more information, visit www.ncemt.ctc.com.

2001 Ship Production Symposium and Expo

June 13–15
Ypsilanti, Michigan

The NCEMT will exhibit its contributions to shipbuilding technology at this event dedicated to "Technology Development, Deployment, Education and Training," and sponsored by The Society of Naval Architects and Marine Engineers, as well as the National Shipbuilding Research Program–Advanced Shipbuilding Enterprise. For more information, visit http://www.sname.org/sections/great_lakes/2001SPS/.

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Concurrent Technologies Corporation (*CTC*) operates the National Center for Excellence in Metalworking Technology (NCEMT) for the U.S. Navy Manufacturing Technology (MANTECH) Program. NCEMT serves as a national resource for developing and disseminating advanced technologies for metalworking products and processes. The NCEMT applies these technologies to solve productivity problems in support of the Navy and Department of Defense needs.

CTC is committed to assisting industry and government achieve world-class competitiveness. Through a unique concurrent engineering framework, *CTC* provides comprehensive solutions that improve our clients' product quality, productivity, and cost effectiveness. The professional staff of *CTC* has the requisite experience, knowledge, and resources to rapidly and effectively meet the diverse needs of our clients by transitioning appropriate science, technology, and management applications.

For further information about topics in this publication or about Concurrent Technologies Corporation, please contact Information Services at (814) 269-2809.

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