METALWORKING TECHNOLOGY UPDATE

Summer 2001

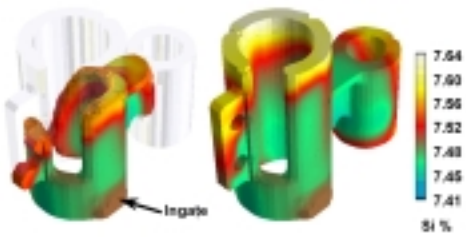
NCEMT Develops Metalworking Optimization

Process models are useful tools for understanding how materials respond to processing conditions such as heating, forming or fluid interaction. They are based on fundamental principles of physics and mathematics. Frequently these models are computer-based to account for the complex interrelated phenomena that are typical of many metalworking processes. Process models account for material response (e.g., temperature, forces and flow paths) and how a workpiece interacts with the process tooling and the surroundings. The NCEMT has succeeded in developing a wide variety of process modeling tools and applying them to solve Navy problems and helping to develop new processes.

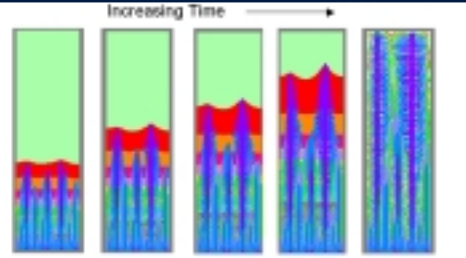
One example of this work is the prediction of particle segregation during centrifugal casting of metal matrix composites. Segregation of the reinforcing particles allows for creation of an inexpensive, functionally graded structure. As a recently exploited application for the centrifugal casting process, optimum process conditions were not well understood. By looking at conditions such as mold rotation speed, pouring temperature, mold preheat temperature, and particle size, the NCEMT was able to use process models to significantly narrow the process window for production trials while ensuring compliance with the limitations of the production equipment at the foundry where the casting trials are being conducted.

As a result, more focused, less costly experiments are now needed to arrive at the best casting methods for manufacturing high-quality castings. The NCEMT has conservatively estimated that both a six-month reduction in process development time and a $100,000 reduction in development costs have been realized through the use of these models.

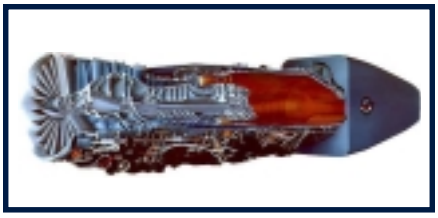
Process models have been developed by the NCEMT for a wide variety of metalworking processes (see examples in accompanying figures) including forming, casting, powder metal consolidation, heat treating, joining, semi-solid metalworking, wire drawing, rolling, machining, surfacing, and melting. Some of these models provide quick, approximate answers to help to steer an analyst in the right direction in defining a process design. These models are useful in evaluating a variety of process design themes or when time doesn't permit a detailed analysis. Other more comprehensive and accurate models provide significant process details from which precise designs can be established. To learn more about process modeling at the NCEMT, visit the NCEMT Web site at www.ncemt.ctc.com. ■



Segregation During Filling of Semi-solid Part



Crystal Growth and Segregation Patterns in Castings



NCEMT Supports NSRP ASE

The NCEMT is supporting the National Shipbuilding Research Program Advanced Shipbuilding Enterprise (NSRP ASE) through performance of several projects led by its Ship Production Panels. With support from the Office of Naval Research, the NCEMT collaborated with the Shipyard Production Process Technologies Panel (SP-16), the Welding Technologies Panel (SP-7) and the Surface Preparation and Coatings Panel (SP-3) to produce the 2000 *Shipyard State-of-the-Art Report*. Leveraging the Environmental Technologies and Manufacturing Technologies capabilities available at Concurrent Technologies Corporation (*CTC*), the NCEMT is currently supporting the Environmental Panel (SP-1) with the production of its contributions to the 2001 *Shipyard State-of-the-Art Report.*

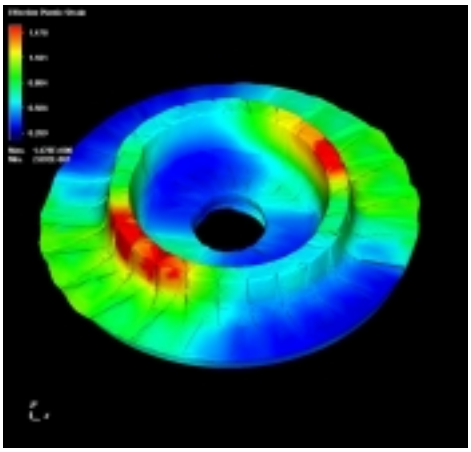
The NCEMT is also supporting Surface Preparation and Coatings Panel (SP-3) with an economic analysis of waterjet technology.

In addition to operating the NCEMT, *CTC* operates the National Defense Center for Environmental Excellence (NDCEE), a Tri-service Program that provides environmental support to the Department of Defense. This experience and expertise is being leveraged to benefit NSRP ASE through the identification of future environmental technologies and practices, emerging technologies, and strategies. ■

Ladish Co., Inc.; Wyman-Gordon; and Firth Rixson Viking Benefit from NCEMT Forgings Process Modeling Technologies

To reach the affordability goals of the Joint Strike Fighter (JSF) and other military aircraft, the Air Force/Navy Forging Supplier Initiative aims to lower by 35–40 percent the acquisition costs of aerospace forgings like airfoils, cases, integrally bladed rotors, rings and shafts. A Pratt & Whitney Engines-led team has been awarded an Air Force contract to achieve these cost reductions on specific forged parts in the JSF-F119 engine. The NCEMT has management responsibility for a Navy MANTECH project that supports the technical activities of forging vendors Ladish Co, Wyman-Gordon, and Firth Rixson Viking and helps them to achieve their technical and cost targets.

Current ring-rolled components have an unusually high buy-to-fly ratio of 12-14 and the raw materials (e.g., Ti-6-4 and IN718) are expensive. Until recently, there were no design and simulation tools suitable for use by ring-rolling suppliers. To rapidly evaluate ring-rolling preforms, develop die shapes and generate inputs for a detailed finite element analysis, the NCEMT; Applied Optimization, Inc., Centerville, OH; and Ohio University, Athens, OH have developed geometrical and upper-bound elemental techniques (UBET). These simulation tools have execution times on the order of minutes and have been released to Firth Rixson Viking.



The die-workpiece interface conditions are an important reason for disagreements between simulations and practice and between sub-scale tests and full-scale trials. Two other important factors are geometric complexity and constitutive behavior. The NCEMT is developing an enhanced tribology module for modeling the evolution of interface friction and heat transfer during hot forging in association with the University of Notre Dame, Notre Dame, IN. The first version of this model has been implemented for isothermal, axisymmetric forgings (superalloy engine disks) as a DEFORM-2D user-subroutine and released to Ladish Co. and Wyman-Gordon. ■

NCEMT Improves Processes for High-Strength Steel Castings and Forgings for Navy

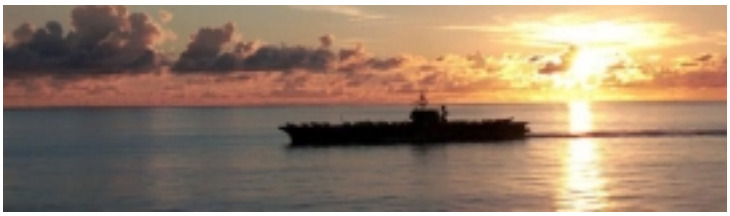
U.S. Navy aircraft carriers (CVNs) and submarines (SSNs) utilize approximately 250 tons each of high-yield strength HY-80 ksi and HY-100 ksi steel castings and forgings. Studies by the Naval Sea Systems Command (NAVSEA) identified several problems with HY-80 and HY-100 steels—hydrogen-assisted cracking (HAC) in castings, excessive hardness and low toughness resulting from improper heat treatment of the casting, and high costs due to preheat requirements when welding the castings or forgings during construction. NAVSEA requested the NCEMT to solve these problems and reduce fabrication costs by eliminating preheating HY-80/100 components prior to welding.

The demonstrated technology will provide steel castings and forgings having nominal yield strengths of 80/100 with improved weldability and resistance to HAC.

To address the hydrogen problem, the NCEMT established thermal soaking treatments for HAC problems in HY-80/100 castings. The thermophysical and metallurgical properties that are required to model the diffusion of hydrogen in HY-80/100 were collected from literature or experiments. These numerical models were then used to improve prediction of residual stresses and hydrogen distribution in castings as a function of geometry, initial hydrogen content in the casting, and processing conditions. These models provided tools to determine optimum thermal soaking treatments. The technology has been transferred to the Navy, shipyards, and foundries. These tools will enable foundries to determine probable HAC locations and lead to process improvements for reduced or redistributed residual stresses and/or hydrogen levels in castings.

Eliminating component preheating prior to welding could result in $1.65-million annual savings based on annual use of 1,100 tons of HY-80/100 castings and forgings and preheating costs averaging $1,500 per ton. An alloy composition that is more resistant to improper heat treatment will also allow certification of new sources for large steel castings. This increase in competition is expected to result in a five-percent acquisition cost savings. Technology that is developed under this project would be applicable to other high-strength steel castings and forgings in Navy ships and in other Department of Defense components.

To reduce or eliminate the welding preheat requirements, the NCEMT investigated alternative casting and forging alloy compositions similar to HSLA-80 and HSLA-100 by looking at casting and forging characteristics, optimization of heat treatment, mechanical properties, weldability, and demonstration of minimal sensitivity to HAC. Minor chemistry changes (within material specifications) and an exhaustive heat-treatment matrix were conducted on candidate casting materials. The conclusion was that major chemistry alterations are required for the castings to concurrently meet the requisite strength and toughness levels for the military-unique service conditions. On the other hand, two forging compositions have shown promise and an HSLA-100 alloy has been selected for further evaluation. ■



Program News

To strengthen its ties with Navy shipbuilders and assure that its projects are clearly focused on their needs, the NCEMT has appointed representatives to key Ship Production Panels of the National Shipbuilding Research Program (NSRP). The mission of each representative is to disseminate NCEMT project results and capabilities that benefit the shipbuilding industry, develop teaming arrangements with shipyards, identify industry needs that could be met by matching funds for NCEMT projects, and identify qualified subcontractors.

For more information on NCEMT activities relevant to specific NSRP panels, contact one of the following *CTC*/NCEMT representatives.

Shipyard Production Process Technologies (SP-16)
Larry S. Knipple
(814) 269-2568
knipple@ctc.com

Systems Technologies (SP-12)
Heather R. Moyer
(814) 269-6474
moyer@ctc.com

Product Design and Materials Technologies (SP-14)
Gerard (Jeff) Mercier
(814) 269-2696
mercierg@ctc.com

Facilities and Tooling (SP-13)
Bruce E. Williams
(814) 269-2573
wiliamsb@ctc.com

Welding Technologies (SP-7)
Paul J. Konkol
(412) 577-2654 (814) 269-6489
konkol@ctc.com

Surface Preparation and Coatings (SP-3)
Michael J. Docherty
(814) 269-6462
docherty@ctc.com

Environmental Technology (SP-1)
Georgette Kotsagrelos
(412) 577-2655
kotsagre@ctc.com

Calendar of Events

On September 5–6, the NCEMT is facilitating *Shipbuilding Technologies 2001: A Shipbuilding Technologies Information Exchange* at the Beau Rivage Resort & Casino in Biloxi, Mississippi. The exchange is sponsored by the Office of Naval Research – Navy MANTECH Program and the National Shipbulding Research Program Advanced Shipbuilding Enterprise (NSRP ASE).

The Naval Sea Systems Command keynote will be given by Vice Admiral George P. Nanos, Jr., Commander, NAVSEA. The NSRP ASE keynote speaker will be Rear Admiral Paul M. Robinson, U.S. Navy (retired), Vice-President of Operations, Northrop Grumman Litton Ingalls Shipbuilding. The closing keynote address will be given by Rear Admiral Jay M. Cohen, Chief of Naval Research. The Luncheon Speaker will be Robert L. Merchant, USS Cole Restoration Program Manager, Northrop Grumman Litton Ingalls Shipbuilding. A first plenary panel discussion, Industry/Navy Cooperation in Shipbuilding Technology Development, will be moderated by Michael L. Powell, Director, Technology Development, Newport News Shipbuilding. A second discussion, National Shipbuilding Issues, will be moderated by John B. Todaro, Director, Office of Technology Transition, Department of Defense. Thirty technical presentations will be given under the following concurrent Technical Sessions: Materials, Standards, and Design Technologies; Production Processes; and Business Processes. The meeting concludes with a tour of Northrop Grumman Litton Ingalls Shipyards in Pascagoula, which includes the USS Cole Repair Dock. ■

Concurrent Technologies Corporation

NCEMT Program Manager
Richard J. Henry

Writer/Editor
Debbie Roman Eisenberg

Design and Production
Amy J. Stawarz

Production Assistant
Donald Cekada

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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