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The Future in Ship Doors – Lattice Block Materials

By Tony Furio and Mary Zoccola

Developing new technologies opens doors – literally. In this case, a new metal technology called Lattice Block Material (LBM) is being employed to improve surface ship doors in the future.

"This technology is the biggest thing in structures and materials for a long time," explained Tony Furio (652). "It brings together structures and materials experts, as well as other groups throughout the Navy."

Basic Lattice Block Material (LBM) Configuration. 300 dpi.

Jonathan Aerospace Materials Corporation (JAMCORP[a]) of Boston, Massachusetts, a small business specializing in start-up manufacturing design and materials, pioneered this technology. Participants include NSWCCD, NAVSEA, PEO Carriers, ONR, General Dynamics (Bath Iron Works), and JAMCORP. The NSWCCD teams consists of Furio, the technical point of contact; Dr. William Messick (0115), program consultant; Joe Cavallaro (603–retired), materials consultant; Eric Rasmussen (652), program advisor; Natale S. Nappi (65-retired), design consultant; Himat Garala (655), finite element modeling; Brian Snyder and Young Hwang (652), finite element modeling; Xian Zhang (Jie) (614), metallurgical evaluation and testing; Jeff Warren and Dr. Kirsten Lipetzky (615), non-destructive evaluation; and Frank McMullen (978), Fleet support.

Dr. Lee Buchanan, then-Assistant Secretary of the Navy, approved a $2-million program in August 2000 to certify an interior watertight door for the CNO/NAVSEA Smart Ship initiative. A one-year test demonstration of the prototype door is scheduled to begin on USS *Carl Vinson* (CVN 70) in FY 02. If successful, LBM watertight doors will be the standard for the Fleet.

LBM Technology

LBM technology involves the production of lightweight metals, which are cast by pouring the molten material into molds or flasks containing sand. The part shape is formed by cope (top mold) and drag (bottom mold) tooling made out of either a resin-based material or aluminum, which forms the part impressions in the sand. The LBM is then formed from a series of three steel plate dies that are interconnected to form the shell core mold. This mold contains the machined impressions of the LBM ligaments. The shell core tooling is filled with sand and heated to form each interconnecting tetrahedron. The cores are then ready to be placed in the main mold that contains the sand impressions made by the cope and drag tools.

Current Door Problems and the New Design

Interior watertight doors have conventional steel plate and T-beam welded construction, a design dating from World War II. Maintenance problems stem from the initial fabrications process of welding thin sheet metal to stiffeners. This causes excessive distortions, which affect other door hardware such as hinges, linkages, bearings, and seals. Operation of the doors becomes more difficult with each opening and closing, and the Navy spends 15 to 18 million dollars annually repairing them. To combat this problem, Bath Iron Works (BIW) developed an improved door design for the LPD 17. Their idea of creating a stiffer door in relationship to the bulkhead is a partial solution; however, the doors are very heavy and require significant welding, which results in higher costs, as well. The new LBM technology has the potential of overcoming the weight problem, as well as welding distortions. Using the same BIW design concept, new doors will be constructed from stainless steel, which will minimize corrosion and maintenance costs. Additionally, the stainless steel LBM doors will be designed to withstand 15 psi pressure, a requirement for their future applications as exterior doors.

The program has very high visibility. Then-Secretary of the Navy Richard Danzig had taken this as a personal goal to develop maintenance-free and cost-effective doors, since so much money was being spent repairing doors in the Fleet.

Early History

Several years ago, the Defense Advanced Research Projects Agency (DARPA) sponsored an ultra-light weight porous foam metals program. Dr. Steve Fishman (ONR 332), program manager for missiles and materials headed this effort. Fishman discovered LBM technology through his work with industry. Although LBM is not a foam material, he recognized its potential as a new lightweight structure which can be cast in one piece and eliminate or significantly reduce welding. However, the technology needed to be demonstrated. To this end, Fishman began a Small Business Innovation Research (SBIR) program funded through Phase I.

Layup of triangular cores for casting lattice structure. ***300 dpi.***

Left. Basic LBM interior watertight door design with cover trim. *300 dpi.*

JAMCORP built a large 4-foot-cube out of carbon steel (with 1-inch diameter elements and 8-inch primary node spacing) as a demonstration, and proved that the shell core tooling can be used to form LBM. LBM technology seemed so promising that JAMCORP was awarded a Phase II contract to refine the design, tooling, and casting process. But, the effort still lacked an application. At this point, Cavallaro and Messick learned about the SBIR and became interested in further study. They brought Furio into the project to focus on an application. His extensive experience and success with other lightweight metallic structures included NAVTRUSS[a] and LASer Corrugated CORe (LASCOR).

Noting the promise of LBM technology, Corrado provided funding for a weight feasibility study. This study concluded that the LBM structure was comparable to and possibly better than other lightweight structures under consideration. Working with General Dynamics Electric Boat Division, a follow-on study involved portable decking for machinery spaces on the Virginia Class submarines. From those studies, LBM proved successful from a weight standpoint and showed cost advantages, as well.

Currently, the doors are destined for surface ships. Additional applications of this casting technology will be considered in the future. Since LBM can be cast with varying curvatures, this technology could also be used for hatches, weapons elevator doors, and control surfaces on both surface ships and submarines. OPNAV selects mature technologies for participation in the Design Improvement Program for submarines. It is hoped that LBM will be included in that process.

Making a Deal

Fishman, seeing the potential benefits, was successful in obtaining a 2-year, $400-thousand effort to carry on the technology with emphasis on applications. He briefed ASN's Chief Technology Officer, Dr. James DeCorpo, and his staff. Ken Brayton and Sharon Beerman-Curtin championed the technology from NAVSEA and the PEO Carrier Office. From this presentation, a deal was brokered between the ASN, PEO Carriers, and NSWCCD to help qualify and transition the new LBM technology rapidly into the Fleet. As part of the plan, ASN provided funding for ONR to initiate contracts with the two commercial vendor participants, JAMCORP and BIW, to develop, manufacture, and install the new LBM doors. The Division is the first lab to get such a deal, which bridges the gap between 6.2 and 6.3 funding. In such studies, money is often lacking for research and Fleet implementation. Deals are reserved for low-medium risk and relatively quick Fleet implementation.

Current Development

Current tasking totals $2 million to develop the watertight door. The concept will use the basic BIW design for the LPD 17 consisting of a stiff frame and panel, but will "go out of the box" and incorporate LBM and new commercial, off-the-shelf hinges and opening and closing mechanisms.

The doors are now in the early stages of development. A new type of cooperative work plan called a Concurrent Application Development and Research Effort (CADRE) has been established. CADRE is a process in which the research about the technology and development of a specific application, occur simultaneously and interactively. JAMCORP is producing the door; BIW will provide technical consultation and door design and hardware, and NSWCCD is conducting research and managing the qualification and testing of the new doors. The first stage is to produce a preliminary or alpha design, based on the best available information. In this case, we have used data from the SBIR demonstrated door and hardware designs from the manufacturers. From here, iterative targeting is conducted, meaning the door is repeatedly cast and results assessed until a door is produced that meets all the objectives of the alpha design. During this process, NSWCCD will perform finite element modeling (FEM) analysis and recommendations based on their research to help optimize for both weight and cost.

Fleet Demonstration

The prototype doors will be tested under shock, pressure, and vibration. Pending certification and time schedule, LBM doors will be targeted for purchase for the Smart Carrier program and installed on USS *Carl Vinson* (CVN 70) in the fall of 2002. If a one-year trial is successful, the LBM doors will become the standard for Fleet surface ships.

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